US011510027B2

(12) **United States Patent**
    Lundmark

(10) **Patent No.:     US 11,510,027 B2**
(45) **Date of Patent:        Nov. 22, 2022**

(54) **SYSTEMS AND METHODS FOR VIRTUAL AND AUGMENTED REALITY**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/257,814**

(22) PCT Filed: **Jul. 3, 2019**

(86) PCT No.: **PCT/US2019/040544**
    § 371 (c)(1),
    (2) Date: **Jan. 4, 2021**

(87) PCT Pub. No.: **WO2020/010226**
    PCT Pub. Date: **Jan. 9, 2020**

(65) **Prior Publication Data**
    US 2021/0297808 A1      Sep. 23, 2021
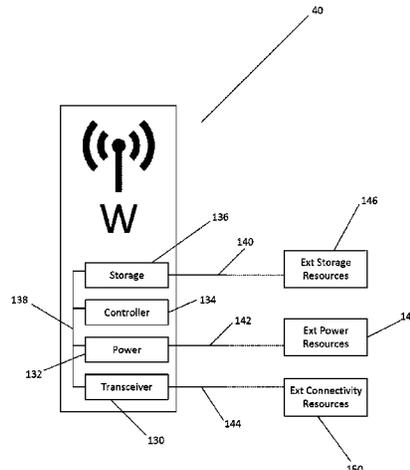
**Related U.S. Application Data**

(60) Provisional application No. 62/693,891, filed on Jul. 3, 2018.

(51) **Int. Cl.**
    *H04W 4/02*          (2018.01)
    *G02B 27/01*         (2006.01)
            (Continued)

(52) **U.S. Cl.**
    CPC ........ *H04W 4/023* (2013.01); *G02B 27/0172* (2013.01); *G06K 7/1408* (2013.01); *G06T 19/006* (2013.01); *H04W 4/025* (2013.01)

(58) **Field of Classification Search**
    CPC ...... H04W 4/023; H04W 4/025; G06T 19/006
            (Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,344,092  A      8/1982   Miller
4,652,930  A      3/1987   Crawford
              (Continued)

FOREIGN PATENT DOCUMENTS

CN       104603675  A      5/2015
CN       107683497  A1     2/2018
              (Continued)

OTHER PUBLICATIONS

"ARToolKit: Hardware", https://web.archive.org/web/20051013062315/
http://www.hitl.washington.edu:80/artoolkit/documentation/hardware.
htm (downloaded Oct. 26, 2020), Oct. 13, 2015, (3 pages).
              (Continued)

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(57) **ABSTRACT**

This disclosure describes techniques for receiving information that is wirelessly transmitted to a mobile computing system by wireless devices that are proximal to a route being travelled by the mobile computing system, and presenting at least a portion of the received information through a display of the mobile computing system. The information can be displayed according to a computing experience that is determined for a user of the mobile computing system (e.g., user-selected, inferred based on a stored schedule of the user, and so forth). Different sets of location-based information can be transmitted to the mobile computing system from different wireless devices that the mobile computing system comes into proximity with while traveling along a route. In some instances, the information can be locally stored on the wireless device(s) to reduce latency.

**20 Claims, 9 Drawing Sheets**

(51) **Int. Cl.**
    *G06K 7/14*        (2006.01)
    *G06T 19/00*     (2011.01)

(58) **Field of Classification Search**
    USPC ...................................................... 455/456.1
    See application file for complete search history.

(56)           **References Cited**

U.S. PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| 4,810,080 A | 3/1989 | Grendol et al. | |
| 4,997,268 A | 3/1991 | Dauvergne | |
| 5,007,727 A | 4/1991 | Kahaney et al. | |
| 5,074,295 A | 12/1991 | Willis | |
| 5,240,220 A | 8/1993 | Elberbaum | |
| 5,251,635 A | 10/1993 | Dumoulin et al. | |
| 5,410,763 A | 5/1995 | Bolle | |
| 5,455,625 A | 10/1995 | Englander | |
| 5,495,286 A | 2/1996 | Adair | |
| 5,497,463 A | 3/1996 | Stein et al. | |
| 5,682,255 A | 10/1997 | Friesem et al. | |
| 5,826,092 A | 10/1998 | Flannery | |
| 5,854,872 A | 12/1998 | Tai | |
| 5,864,365 A | 1/1999 | Sramek et al. | |
| 5,937,202 A | 8/1999 | Crosetto | |
| 6,012,811 A | 1/2000 | Chao et al. | |
| 6,016,160 A | 1/2000 | Coombs et al. | |
| 6,076,927 A | 6/2000 | Owens | |
| 6,117,923 A | 9/2000 | Amagai et al. | |
| 6,124,977 A | 9/2000 | Takahashi | |
| 6,191,809 B1 | 2/2001 | Hori et al. | |
| 6,375,369 B1 | 4/2002 | Schneider et al. | |
| 6,385,735 B1 | 5/2002 | Wilson | |
| 6,538,655 B1 | 3/2003 | Kubota | |
| 6,541,736 B1 | 4/2003 | Huang et al. | |
| 6,757,068 B2 | 6/2004 | Foxlin | |
| 7,046,515 B1 | 5/2006 | Wyatt | |
| 7,051,219 B2 | 5/2006 | Hwang | |
| 7,076,674 B2 | 7/2006 | Cervantes | |
| 7,111,290 B1 | 9/2006 | Yates, Jr. | |
| 7,119,819 B1 | 10/2006 | Robertson et al. | |
| 7,219,245 B1 | 5/2007 | Raghuvanshi | |
| 7,431,453 B2 | 10/2008 | Hogan | |
| 7,542,040 B2 | 6/2009 | Templeman | |
| 7,573,640 B2 | 8/2009 | Nivon et al. | |
| 7,724,980 B1 | 5/2010 | Shenzhi | |
| 7,751,662 B2 | 7/2010 | Kleemann | |
| 7,758,185 B2 | 7/2010 | Lewis | |
| 8,060,759 B1 | 11/2011 | Arnan et al. | |
| 8,120,851 B2 | 2/2012 | Iwasa | |
| 8,214,660 B2 | 7/2012 | Capps, Jr. | |
| 8,246,408 B2 | 8/2012 | Elliot | |
| 8,353,594 B2 | 1/2013 | Lewis | |
| 8,508,676 B2 | 8/2013 | Silverstein et al. | |
| 8,547,638 B2 | 10/2013 | Levola | |
| 8,605,764 B1 | 10/2013 | Rothaar et al. | |
| 8,619,365 B2 | 12/2013 | Harris et al. | |
| 8,696,113 B2 | 4/2014 | Lewis | |
| 8,698,701 B2 | 4/2014 | Margulis | |
| 8,733,927 B1 | 5/2014 | Lewis | |
| 8,736,636 B2 | 5/2014 | Kang | |
| 8,759,929 B2 | 6/2014 | Shiozawa et al. | |
| 8,793,770 B2 | 7/2014 | Lim | |
| 8,823,855 B2 | 9/2014 | Hwang | |
| 8,847,988 B2 | 9/2014 | Geisner et al. | |
| 8,874,673 B2 | 10/2014 | Kim | |
| 9,010,929 B2 | 4/2015 | Lewis | |
| 9,015,501 B2 | 4/2015 | Gee | |
| 9,086,537 B2 | 7/2015 | Iwasa et al. | |
| 9,095,437 B2 | 8/2015 | Boyden et al. | |
| 9,239,473 B2 | 1/2016 | Lewis | |
| 9,244,293 B2 | 1/2016 | Lewis | |
| 9,244,533 B2 | 1/2016 | Friend et al. | |
| 9,383,823 B2 | 7/2016 | Geisner et al. | |
| 9,489,027 B1 | 11/2016 | Ogletree | |
| 9,519,305 B2 | 12/2016 | Wolfe | |
| 9,581,820 B2 | 2/2017 | Robbins | |
| 9,582,060 B2 | 2/2017 | Balatsos | |
| 9,658,473 B2 | 5/2017 | Lewis | |
| 9,671,566 B2 | 6/2017 | Abovitz et al. | |
| 9,671,615 B1 | 6/2017 | Vallius et al. | |
| 9,696,795 B2 | 7/2017 | Marcolina et al. | |
| 9,798,144 B2 | 10/2017 | Sako et al. | |
| 9,874,664 B2 | 1/2018 | Stevens et al. | |
| 9,918,058 B2 | 3/2018 | Takahasi et al. | |
| 9,930,486 B2 * | 3/2018 | Mycek .................... G01S 5/02 | |
| 9,955,862 B2 | 5/2018 | Freeman et al. | |
| 9,978,118 B1 | 5/2018 | Ozgumer et al. | |
| 9,996,797 B1 | 6/2018 | Holz et al. | |
| 10,018,844 B2 | 7/2018 | Levola et al. | |
| 10,082,865 B1 | 9/2018 | Raynal et al. | |
| 10,151,937 B2 | 12/2018 | Lewis | |
| 10,185,147 B2 | 1/2019 | Lewis | |
| 10,218,679 B1 | 2/2019 | Jawahar | |
| 10,241,545 B1 | 3/2019 | Richards et al. | |
| 10,317,680 B1 | 6/2019 | Richards et al. | |
| 10,436,594 B2 * | 10/2019 | Belt ................... G01C 21/3652 | |
| 10,516,853 B1 | 12/2019 | Gibson et al. | |
| 10,551,879 B1 | 2/2020 | Richards et al. | |
| 10,578,870 B2 | 3/2020 | Kimmel | |
| 10,698,202 B2 | 6/2020 | Kimmel et al. | |
| 10,825,424 B2 | 11/2020 | Zhang | |
| 10,856,107 B2 * | 12/2020 | Mycek ................... H04W 4/30 | |
| 10,987,176 B2 | 4/2021 | Poltaretskyi et al. | |
| 11,190,681 B1 | 11/2021 | Brook et al. | |
| 11,209,656 B1 | 12/2021 | Choi et al. | |
| 11,236,993 B1 | 2/2022 | Hall et al. | |
| 2001/0010598 A1 | 8/2001 | Aritake et al. | |
| 2002/0007463 A1 | 1/2002 | Fung | |
| 2002/0108064 A1 | 2/2002 | Nunally | |
| 2002/0063913 A1 | 5/2002 | Nakamura et al. | |
| 2002/0071050 A1 | 6/2002 | Homberg | |
| 2002/0122648 A1 | 9/2002 | Mule' et al. | |
| 2002/0140848 A1 | 10/2002 | Cooper et al. | |
| 2003/0028816 A1 | 2/2003 | Bacon | |
| 2003/0048456 A1 | 3/2003 | Hill | |
| 2003/0067685 A1 | 4/2003 | Niv | |
| 2003/0077458 A1 | 4/2003 | Korenaga et al. | |
| 2003/0115494 A1 | 6/2003 | Cervantes | |
| 2003/0218614 A1 | 11/2003 | Lavelle et al. | |
| 2003/0219992 A1 | 11/2003 | Schaper | |
| 2003/0226047 A1 | 12/2003 | Park | |
| 2004/0001533 A1 | 1/2004 | Tran et al. | |
| 2004/0021600 A1 | 2/2004 | Wittenberg | |
| 2004/0025069 A1 | 2/2004 | Gary et al. | |
| 2004/0042377 A1 | 3/2004 | Nikoloai et al. | |
| 2004/0073822 A1 | 4/2004 | Greco | |
| 2004/0073825 A1 | 4/2004 | Itoh | |
| 2004/0111248 A1 | 6/2004 | Granny et al. | |
| 2004/0174496 A1 | 9/2004 | Ji et al. | |
| 2004/0186902 A1 | 9/2004 | Stewart | |
| 2004/0201857 A1 | 10/2004 | Foxlin | |
| 2004/0238732 A1 | 12/2004 | State et al. | |
| 2004/0240072 A1 | 12/2004 | Schindler et al. | |
| 2004/0246391 A1 | 12/2004 | Travis | |
| 2004/0268159 A1 | 12/2004 | Aasheim et al. | |
| 2005/0001977 A1 | 1/2005 | Zelman | |
| 2005/0034002 A1 | 2/2005 | Flautner | |
| 2005/0157159 A1 | 7/2005 | Komiya et al. | |
| 2005/0177385 A1 | 8/2005 | Hull | |
| 2005/0273792 A1 | 12/2005 | Inohara et al. | |
| 2006/0013435 A1 | 1/2006 | Rhoads | |
| 2006/0015821 A1 | 1/2006 | Jacques Parker et al. | |
| 2006/0019723 A1 | 1/2006 | Vorenkamp | |
| 2006/0038880 A1 | 2/2006 | Starkweather et al. | |
| 2006/0050224 A1 | 3/2006 | Smith | |
| 2006/0090092 A1 | 4/2006 | Verhulst | |
| 2006/0126181 A1 | 6/2006 | Levola | |
| 2006/0129852 A1 | 6/2006 | Bonola | |
| 2006/0132914 A1 | 6/2006 | Weiss et al. | |
| 2006/0179329 A1 | 8/2006 | Terechko | |
| 2006/0221448 A1 | 10/2006 | Nivon et al. | |
| 2006/0228073 A1 | 10/2006 | Mukawa et al. | |
| 2006/0250322 A1 | 11/2006 | Hall et al. | |
| 2006/0259621 A1 | 11/2006 | Ranganathan | |
| 2006/0268220 A1 | 11/2006 | Hogan | |

(56)   **References Cited**

U.S. PATENT DOCUMENTS

| | | |
|---|---|---|
| 2007/0058248 A1 | 3/2007 | Nguyen et al. |
| 2007/0103836 A1 | 5/2007 | Oh |
| 2007/0124730 A1 | 5/2007 | Pytel |
| 2007/0159673 A1 | 7/2007 | Freeman et al. |
| 2007/0188837 A1 | 8/2007 | Shimizu et al. |
| 2007/0198886 A1 | 8/2007 | Saito |
| 2007/0204672 A1 | 9/2007 | Huang et al. |
| 2007/0213952 A1 | 9/2007 | Cirelli |
| 2007/0283247 A1 | 12/2007 | Brenneman et al. |
| 2008/0002259 A1 | 1/2008 | Ishizawa et al. |
| 2008/0002260 A1 | 1/2008 | Arrouy et al. |
| 2008/0043334 A1 | 2/2008 | Itzkovitch et al. |
| 2008/0046773 A1 | 2/2008 | Ham |
| 2008/0063802 A1 | 3/2008 | Maula et al. |
| 2008/0068557 A1 | 3/2008 | Menduni et al. |
| 2008/0146942 A1 | 6/2008 | Dala-Krishna |
| 2008/0173036 A1 | 7/2008 | Willaims |
| 2008/0177506 A1 | 7/2008 | Kim |
| 2008/0205838 A1 | 8/2008 | Crippa et al. |
| 2008/0215907 A1 | 9/2008 | Wilson |
| 2008/0225393 A1 | 9/2008 | Rinko |
| 2008/0316768 A1 | 12/2008 | Travis |
| 2009/0153797 A1 | 6/2009 | Allon et al. |
| 2009/0224416 A1 | 9/2009 | Laakkonen et al. |
| 2009/0245730 A1 | 10/2009 | Kleemann |
| 2009/0310633 A1 | 12/2009 | Ikegami |
| 2010/0005326 A1 | 1/2010 | Archer |
| 2010/0019962 A1 | 1/2010 | Fujita |
| 2010/0056274 A1 | 3/2010 | Uusitalo et al. |
| 2010/0063854 A1 | 3/2010 | Purvis et al. |
| 2010/0079841 A1 | 4/2010 | Levola |
| 2010/0153934 A1 | 6/2010 | Lachner |
| 2010/0194632 A1 | 8/2010 | Raento et al. |
| 2010/0232016 A1 | 9/2010 | Landa et al. |
| 2010/0232031 A1 | 9/2010 | Batchko et al. |
| 2010/0244168 A1 | 9/2010 | Shiozawa et al. |
| 2010/0296163 A1 | 11/2010 | Sarikko |
| 2011/0021263 A1 | 1/2011 | Anderson et al. |
| 2011/0022870 A1 | 1/2011 | Mcgrane |
| 2011/0050655 A1 | 3/2011 | Mukawa |
| 2011/0122240 A1 | 5/2011 | Becker |
| 2011/0145617 A1 | 6/2011 | Thomson et al. |
| 2011/0170801 A1 | 7/2011 | Lu et al. |
| 2011/0218733 A1 | 9/2011 | Hamza et al. |
| 2011/0286735 A1 | 11/2011 | Temblay |
| 2011/0291969 A1 | 12/2011 | Rashid et al. |
| 2012/0011389 A1 | 1/2012 | Driesen |
| 2012/0050535 A1 | 3/2012 | Densham et al. |
| 2012/0075501 A1 | 3/2012 | Oyagi et al. |
| 2012/0081392 A1 | 4/2012 | Arthur |
| 2012/0089854 A1 | 4/2012 | Breakstone |
| 2012/0113235 A1 | 5/2012 | Shintani |
| 2012/0127062 A1 | 5/2012 | Bar-Zeev et al. |
| 2012/0154557 A1 | 6/2012 | Perez et al. |
| 2012/0218301 A1 | 8/2012 | Miller |
| 2012/0246506 A1 | 9/2012 | Knight |
| 2012/0249416 A1 | 10/2012 | Maciocci et al. |
| 2012/0249741 A1 | 10/2012 | Maciocci et al. |
| 2012/0260083 A1 | 10/2012 | Andrews |
| 2012/0307075 A1 | 12/2012 | Margalitq |
| 2012/0307362 A1 | 12/2012 | Silverstein et al. |
| 2012/0314959 A1 | 12/2012 | White et al. |
| 2012/0320460 A1 | 12/2012 | Levola |
| 2012/0326948 A1 | 12/2012 | Crocco et al. |
| 2013/0021486 A1 | 1/2013 | Richardon |
| 2013/0050258 A1 | 2/2013 | Liu et al. |
| 2013/0050833 A1 | 2/2013 | Lewis et al. |
| 2013/0051730 A1 | 2/2013 | Travers et al. |
| 2013/0077049 A1 | 3/2013 | Bohn |
| 2013/0077170 A1 | 3/2013 | Ukuda |
| 2013/0094148 A1 | 4/2013 | Sloane |
| 2013/0129282 A1 | 5/2013 | Li |
| 2013/0169923 A1 | 7/2013 | Schnoll et al. |
| 2013/0205126 A1 | 8/2013 | Kruglick |
| 2013/0222386 A1 | 8/2013 | Tannhauser et al. |
| 2013/0268257 A1 | 10/2013 | Hu |
| 2013/0278633 A1 | 10/2013 | Ahn et al. |
| 2013/0314789 A1 | 11/2013 | Saarikko et al. |
| 2013/0318276 A1 | 11/2013 | Dalal |
| 2013/0336138 A1 | 12/2013 | Venkatraman et al. |
| 2013/0342564 A1 | 12/2013 | Kinnebrew et al. |
| 2013/0342570 A1 | 12/2013 | Kinnebrew et al. |
| 2013/0342571 A1 | 12/2013 | Kinnebrew et al. |
| 2013/0343408 A1 | 12/2013 | Cook |
| 2014/0013098 A1 | 1/2014 | Yeung |
| 2014/0016821 A1 | 1/2014 | Arth et al. |
| 2014/0022819 A1 | 1/2014 | Oh et al. |
| 2014/0078023 A1 | 3/2014 | Ikeda et al. |
| 2014/0082526 A1 | 3/2014 | Park et al. |
| 2014/0119598 A1 | 5/2014 | Ramachandran et al. |
| 2014/0126769 A1 | 5/2014 | Reitmayr et al. |
| 2014/0140653 A1 | 5/2014 | Brown et al. |
| 2014/0149573 A1 | 5/2014 | Tofighbakhsh et al. |
| 2014/0168260 A1 | 6/2014 | O'Brien et al. |
| 2014/0266987 A1 | 9/2014 | Magyari |
| 2014/0267419 A1 | 9/2014 | Ballard et al. |
| 2014/0274391 A1 | 9/2014 | Stafford |
| 2014/0282105 A1 | 9/2014 | Nordstrom |
| 2014/0340449 A1 | 11/2014 | Plagemann et al. |
| 2014/0359589 A1 | 12/2014 | Kodsky et al. |
| 2014/0375680 A1 | 12/2014 | Ackerman et al. |
| 2015/0005785 A1 | 1/2015 | Olson |
| 2015/0009099 A1 | 1/2015 | Queen |
| 2015/0077312 A1 | 3/2015 | Wang |
| 2015/0097719 A1 | 4/2015 | Balachandreswaran et al. |
| 2015/0123966 A1 | 5/2015 | Newman |
| 2015/0130790 A1 | 5/2015 | Vazquez, II et al. |
| 2015/0134995 A1 | 5/2015 | Park et al. |
| 2015/0138248 A1 | 5/2015 | Schrader |
| 2015/0155939 A1 | 6/2015 | Oshima et al. |
| 2015/0168221 A1 | 6/2015 | Mao et al. |
| 2015/0205126 A1 | 7/2015 | Schowengerdt |
| 2015/0235431 A1 | 8/2015 | Schowengerdt |
| 2015/0253651 A1 | 9/2015 | Russell et al. |
| 2015/0256484 A1 | 9/2015 | Cameron |
| 2015/0269784 A1 | 9/2015 | Miyawaki et al. |
| 2015/0294483 A1 | 10/2015 | Wells et al. |
| 2015/0301955 A1 | 10/2015 | Yakovenko et al. |
| 2015/0338915 A1 | 11/2015 | Publicover et al. |
| 2015/0355481 A1 | 12/2015 | Hilkes et al. |
| 2016/0004102 A1 | 1/2016 | Nisper et al. |
| 2016/0027215 A1 | 1/2016 | Burns et al. |
| 2016/0033770 A1 | 2/2016 | Fujimaki et al. |
| 2016/0077338 A1 | 3/2016 | Robbins et al. |
| 2016/0085285 A1 | 3/2016 | Mangione-Smith |
| 2016/0085300 A1 | 3/2016 | Robbins et al. |
| 2016/0091720 A1 | 3/2016 | Stafford et al. |
| 2016/0093099 A1 | 3/2016 | Bridges |
| 2016/0093269 A1 | 3/2016 | Buckley et al. |
| 2016/0123745 A1 | 5/2016 | Cotier et al. |
| 2016/0180596 A1 | 6/2016 | Gonzalez del Rosario |
| 2016/0187654 A1 | 6/2016 | Border et al. |
| 2016/0191887 A1 | 6/2016 | Casas |
| 2016/0202496 A1 | 7/2016 | Billetz et al. |
| 2016/0217624 A1 | 7/2016 | Finn et al. |
| 2016/0266412 A1 | 9/2016 | Yoshida |
| 2016/0267708 A1 | 9/2016 | Nistico et al. |
| 2016/0274733 A1 | 9/2016 | Hasegawa et al. |
| 2016/0287337 A1 | 10/2016 | Aram et al. |
| 2016/0300388 A1 | 10/2016 | Stafford et al. |
| 2016/0321551 A1 | 11/2016 | Priness et al. |
| 2016/0327798 A1 | 11/2016 | Xiao et al. |
| 2016/0334279 A1 | 11/2016 | Mittleman et al. |
| 2016/0357255 A1 | 12/2016 | Lindh et al. |
| 2016/0370404 A1 | 12/2016 | Quadrat et al. |
| 2016/0370510 A1 | 12/2016 | Thomas |
| 2017/0038607 A1 | 2/2017 | Camara |
| 2017/0060225 A1 | 3/2017 | Zha et al. |
| 2017/0061696 A1 | 3/2017 | Li et al. |
| 2017/0100664 A1 | 4/2017 | Osterhout et al. |
| 2017/0115487 A1 | 4/2017 | Travis |
| 2017/0122725 A1 | 5/2017 | Yeoh et al. |
| 2017/0123526 A1 | 5/2017 | Trail et al. |
| 2017/0127295 A1 | 5/2017 | Black et al. |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | |
|---|---|---|
| 2017/0131569 A1 | 5/2017 | Aschwanden et al. |
| 2017/0147066 A1 | 5/2017 | Katz et al. |
| 2017/0160518 A1 | 6/2017 | Lanman et al. |
| 2017/0161951 A1 | 6/2017 | Fix et al. |
| 2017/0185261 A1 | 6/2017 | Perez et al. |
| 2017/0192239 A1 | 7/2017 | Nakamura et al. |
| 2017/0205903 A1 | 7/2017 | Miller et al. |
| 2017/0206668 A1 | 7/2017 | Poulos et al. |
| 2017/0213388 A1 | 7/2017 | Margolis et al. |
| 2017/0219841 A1 | 8/2017 | Popovich et al. |
| 2017/0232345 A1 | 8/2017 | Rofougaran et al. |
| 2017/0235126 A1 | 8/2017 | DiDomenico |
| 2017/0235129 A1 | 8/2017 | Kamakura |
| 2017/0235142 A1 | 8/2017 | Wall et al. |
| 2017/0235144 A1 | 8/2017 | Piskunov et al. |
| 2017/0235147 A1 | 8/2017 | Kamakura |
| 2017/0243403 A1 | 8/2017 | Daniels et al. |
| 2017/0254832 A1 | 9/2017 | Ho et al. |
| 2017/0256096 A1 | 9/2017 | Faaborg et al. |
| 2017/0258526 A1 | 9/2017 | Lang |
| 2017/0270712 A1 | 9/2017 | Tyson et al. |
| 2017/0281054 A1 | 10/2017 | Stever et al. |
| 2017/0287376 A1 | 10/2017 | Bakar et al. |
| 2017/0293141 A1 | 10/2017 | Schowengerdt et al. |
| 2017/0307886 A1 | 10/2017 | Stenberg et al. |
| 2017/0307891 A1 | 10/2017 | Bucknor et al. |
| 2017/0312032 A1 | 11/2017 | Amanatullah et al. |
| 2017/0322426 A1 | 11/2017 | Tervo |
| 2017/0329137 A1 | 11/2017 | Tervo |
| 2017/0332098 A1 | 11/2017 | Rusanovskyy et al. |
| 2017/0336636 A1 | 11/2017 | Amitai et al. |
| 2017/0357332 A1 | 12/2017 | Balan et al. |
| 2017/0371394 A1 | 12/2017 | Chan |
| 2017/0371661 A1 | 12/2017 | Sparling |
| 2018/0014266 A1 | 1/2018 | Chen |
| 2018/0024289 A1 | 1/2018 | Fattal |
| 2018/0044173 A1 | 2/2018 | Netzer |
| 2018/0052007 A1 | 2/2018 | Teskey et al. |
| 2018/0052501 A1 | 2/2018 | Jones, Jr. et al. |
| 2018/0059305 A1 | 3/2018 | Popovich et al. |
| 2018/0067779 A1 | 3/2018 | Pillalamarri et al. |
| 2018/0070855 A1 | 3/2018 | Eichler |
| 2018/0082480 A1 | 3/2018 | White et al. |
| 2018/0088185 A1 | 3/2018 | Woods et al. |
| 2018/0102981 A1 | 4/2018 | Kurtzman et al. |
| 2018/0108179 A1 | 4/2018 | Tomlin et al. |
| 2018/0114298 A1 | 4/2018 | Malaika et al. |
| 2018/0131907 A1 | 5/2018 | Schmirler et al. |
| 2018/0136466 A1 | 5/2018 | Ko |
| 2018/0144691 A1 | 5/2018 | Choi et al. |
| 2018/0151796 A1 | 5/2018 | Akahane |
| 2018/0188115 A1 | 7/2018 | Hsu et al. |
| 2018/0189568 A1 | 7/2018 | Powderly et al. |
| 2018/0190017 A1 | 7/2018 | Mendez et al. |
| 2018/0191990 A1 | 7/2018 | Motoyama et al. |
| 2018/0250589 A1 | 9/2018 | Cossairt et al. |
| 2018/0284877 A1 | 10/2018 | Klein |
| 2018/0357472 A1 | 12/2018 | Dreessen |
| 2019/0005069 A1 | 1/2019 | Filgueiras de Araujo et al. |
| 2019/0011691 A1 | 1/2019 | Peyman |
| 2019/0056591 A1 | 2/2019 | Tervo et al. |
| 2019/0087015 A1 | 3/2019 | Lam et al. |
| 2019/0101758 A1 | 4/2019 | Zhu et al. |
| 2019/0155439 A1 | 5/2019 | Mukherjee et al. |
| 2019/0158926 A1 | 5/2019 | Kang et al. |
| 2019/0167095 A1 | 6/2019 | Krueger |
| 2019/0172216 A1 | 6/2019 | Ninan et al. |
| 2019/0178654 A1 | 6/2019 | Hare |
| 2019/0196690 A1 | 6/2019 | Chong et al. |
| 2019/0219815 A1 | 7/2019 | Price et al. |
| 2019/0243123 A1 | 8/2019 | Bohn |
| 2019/0318540 A1 | 10/2019 | Piemonte et al. |
| 2019/0321728 A1 | 10/2019 | Imai et al. |
| 2019/0347853 A1 | 11/2019 | Chen et al. |
| 2019/0380792 A1 | 12/2019 | Poltaretskyi et al. |
| 2020/0098188 A1 | 3/2020 | Bar-Zeev et al. |
| 2020/0110928 A1 | 4/2020 | Al Jazaery et al. |
| 2020/0117267 A1 | 4/2020 | Gibson et al. |
| 2020/0117270 A1 | 4/2020 | Gibson et al. |
| 2020/0202759 A1 | 6/2020 | Ukai et al. |
| 2020/0309944 A1 | 10/2020 | Thoresen et al. |
| 2020/0356161 A1 | 11/2020 | Wagner |
| 2020/0368616 A1 | 11/2020 | Delamont |
| 2020/0409528 A1 | 12/2020 | Lee |
| 2021/0008413 A1 | 1/2021 | Asikainen et al. |
| 2021/0033871 A1 | 2/2021 | Jacoby et al. |
| 2021/0041951 A1 | 2/2021 | Gibson et al. |
| 2021/0053820 A1 | 2/2021 | Gurin et al. |
| 2021/0093391 A1 | 4/2021 | Poltaretskyi et al. |
| 2021/0093410 A1 | 4/2021 | Gaborit et al. |
| 2021/0093414 A1 | 4/2021 | Moore et al. |
| 2021/0097886 A1 | 4/2021 | Kuester et al. |
| 2021/0142582 A1 | 5/2021 | Jones et al. |
| 2021/0158627 A1 | 5/2021 | Cossairt et al. |
| 2021/0173480 A1 | 6/2021 | Osterhout et al. |

FOREIGN PATENT DOCUMENTS

| | | |
|---|---|---|
| EP | 0504930 A1 | 3/1992 |
| EP | 0535402 A1 | 4/1993 |
| EP | 0632360 A1 | 1/1995 |
| EP | 1215522 A2 | 6/2002 |
| EP | 1494110 A2 | 1/2005 |
| EP | 1938141 A1 | 7/2008 |
| EP | 1943556 A2 | 7/2008 |
| EP | 2290428 A2 | 3/2011 |
| EP | 2350774 A1 | 8/2011 |
| EP | 1237067 B1 | 1/2016 |
| EP | 3139245 A1 | 3/2017 |
| EP | 3164776 B1 | 5/2017 |
| EP | 3236211 A1 | 10/2017 |
| EP | 2723240 B1 | 8/2018 |
| EP | 2896986 B1 | 2/2021 |
| GB | 2499635 A | 8/2013 |
| GB | 2542853 A | 4/2017 |
| IN | 938/DEL/2004 A | 6/2006 |
| JP | 2002-529806 | 9/2002 |
| JP | 2003-029198 A | 1/2003 |
| JP | 2007-012530 A | 1/2007 |
| JP | 2008-257127 A | 10/2008 |
| JP | 2009-090689 A | 4/2009 |
| JP | 2009-244869 A | 10/2009 |
| JP | 2012-015774 A | 1/2012 |
| JP | 2013-525872 A1 | 6/2013 |
| JP | 2016-85463 A | 5/2016 |
| JP | 2016-516227 A | 6/2016 |
| JP | 6232763 B2 | 11/2017 |
| JP | 6333965 B2 | 5/2018 |
| KR | 2005-0010775 A | 1/2005 |
| KR | 10-1372623 B1 | 3/2014 |
| TW | 201219829 A | 5/2012 |
| TW | 201803289 A | 1/2018 |
| WO | 1991/000565 A2 | 1/1991 |
| WO | 2000/030368 A1 | 6/2000 |
| WO | 2002/071315 A2 | 9/2002 |
| WO | 2004095248 A | 11/2004 |
| WO | 2006132614 A1 | 12/2006 |
| WO | 2007/085682 A1 | 8/2007 |
| WO | 2007/102144 A1 | 9/2007 |
| WO | 2008148927 A1 | 12/2008 |
| WO | 2009/101238 A1 | 8/2009 |
| WO | 2012030787 A2 | 3/2012 |
| WO | 2013/049012 A1 | 4/2013 |
| WO | 2013062701 A1 | 5/2013 |
| WO | 2015143641 A1 | 10/2015 |
| WO | 2016/054092 A1 | 4/2016 |
| WO | 2017004695 A1 | 1/2017 |
| WO | 2017120475 A1 | 7/2017 |
| WO | 2017/203201 A1 | 11/2017 |
| WO | 2018/044537 A1 | 3/2018 |
| WO | 2018087408 A1 | 5/2018 |
| WO | 2018097831 A1 | 5/2018 |

(56)                 **References Cited**

FOREIGN PATENT DOCUMENTS

| WO | 2018/166921 A | 9/2018 |
| WO | 2018166921 A1 | 9/2018 |
| WO | 2019148154 A1 | 8/2019 |

OTHER PUBLICATIONS

Communication Pursuant to Article 94(3) EPC dated Sep. 4, 2019, European Patent Application No. 10793707.0, (4 pages).
European Search Report dated Oct. 15, 2020, European Patent Application No. 20180623.9, (10 pages).
Examination Report dated Jun. 19, 2020, European Patent Application No. 20154750.2, (10 pages).
Extended European Search Report dated May 20, 2020, European Patent Application No. 20154070.5, (7 pages).
Extended European Search Report dated Nov. 3, 2020, European Patent Application No. 18885707.2, (7 pages).
Extended European Search Report dated Nov. 4, 2020, European Patent Application No. 20190980.1, (14 pages).
Extended European Search Report dated Jun. 12, 2017, European Patent Application No. 16207441.3, (8 pages).
Final Office Action dated Aug. 10, 2020, U.S. Appl. No. 16/225,961, (13 pages).
Final Office Action dated Dec. 4, 2019, U.S. Appl. No. 15/564,517, (15 pages).
Final Office Action dated Feb. 19, 2020, U.S. Appl. No. 15/552,897, (17 pages).
Final Office Action dated Nov. 24, 2020, U.S. Appl. No. 16/435,933, (44 pages).
International Search Report and Written Opinion dated Mar. 12, 2020, International PCT Patent Application No. PCT/US19/67919, (14 pages).
International Search Report and Written Opinion dated Aug. 15, 2019, International PCT Patent Application No. PCT/US19/33987, (20 pages).
International Search Report and Written Opinion dated Jun. 15, 2020, International PCT Patent Application No. PCT/US2020/017023, (13 pages).
International Search Report and Written Opinion dated Oct. 16, 2019, International PCT Patent Application No. PCT/US19/43097, (10 pages).
International Search Report and Written Opinion dated Oct. 16, 2019, International PCT Patent Application No. PCT/US19/36275, (10 pages).
International Search Report and Written Opinion dated Oct. 16, 2019, International PCT Patent Application No. PCT/US19/43099, (9 pages).
International Search Report and Written Opinion dated Jun. 17, 2016, International PCT Patent Application No. PCT/FI2016/050172, (9 pages).
International Search Report and Written Opinion dated Oct. 22, 2019, International PCT Patent Application No. PCT/US19/43751, (9 pages).
International Search Report and Written Opinion dated Dec. 23, 2019, International PCT Patent Application No. PCT/US19/44953, (11 pages).
International Search Report and Written Opinion dated May 23, 2019, International PCT Patent Application No. PCT/US18/66514, (17 pages).
International Search Report and Written Opinion dated Sep. 26, 2019, International PCT Patent Application No. PCT/US19/40544, (12 pages).
International Search Report and Written Opinion dated Aug. 27, 2019, International PCT Application No. PCT/US2019/035245, (8 pages).
International Search Report and Written Opinion dated Dec. 27, 2019, International Application No. PCT/US19/47746, (16 pages).

International Search Report and Written Opinion dated Dec. 3, 2020, International Patent Application No. PCT/US20/43596, (25 pages).
International Search Report and Written Opinion dated Sep. 30, 2019, International Patent Application No. PCT/US19/40324, (7 pages).
International Search Report and Written Opinion dated Sep. 4, 2020, International Patent Application No. PCT/US20/31036, (13 pages).
International Search Report and Written Opinion dated Jun. 5, 2020, International Patent Application No. PCT/US20/19871, (9 pages).
International Search Report and Written Opinion dated Aug. 8, 2019, International PCT Patent Application No. PCT/US2019/034763, (8 pages).
International Search Report and Written Opinion dated Oct. 8, 2019, International PCT Patent Application No. PCT/US19/41151, (7 pages).
International Search Report and Written Opinion dated Jan. 9, 2020, International Application No. PCT/US19/55185, (10 pages).
International Search Report and Written Opinion dated Feb. 28, 2019, International Patent Application No. PCT/US18/64686, (8 pages).
International Search Report and Written Opinion dated Feb. 7, 2020, International PCT Patent Application No. PCT/US2019/061265, (11 pages).
International Search Report and Written Opinion dated Jun. 11, 2019, International PCT Application No. PCT/US19/22620, (7 pages).
Invitation to Pay Additional Fees dated Aug. 15, 2019, International PCT Patent Application No. PCT/US19/36275, (2 pages).
Invitation to Pay Additional Fees dated Sep. 24, 2020, International Patent Application No. PCT/US2020/043596, (3 pages).
Invitation to Pay Additional Fees dated Oct. 22, 2019, International PCT Patent Application No. PCT/US19/47746, (2 pages).
Invitation to Pay Additional Fees dated Apr. 3, 2020, International Patent Application No. PCT/US20/17023, (2 pages).
Invitation to Pay Additional Fees dated Oct. 17, 2019, International PCT Patent Application No. PCT/US19/44953, (2 pages).
Non Final Office Action dated Nov. 19. 2019, U.S. Appl. No. 16/355,611, (31 pages).
Non Final Office Action dated Aug. 21, 2019, U.S. Appl. No. 15/564,517, (14 pages).
Non Final Office Action dated Jul. 27, 2020, U.S. Appl. No. 16/435,933, (16 pages).
Non Final Office Action dated Jun. 17, 2020, U.S. Appl. No. 16/682,911, (22 pages).
Non Final Office Action dated Jun. 19, 2020, U.S. Appl. No. 16/225,961, (35 pages).
Non Final Office Action dated Nov. 5, 2020, U.S. Appl. No. 16/530,776, (45 pages).
Non Final Office Action dated Oct. 22, 2019, U.S. Appl. No. 15/859,277, (15 pages).
Non Final Office Action dated Sep. 1, 2020, U.S. Appl. No. 16/214,575, (40 pages).
Notice of Allowance dated Mar. 25, 2020, U.S. Appl. No. 15/564,517, (11 pages).
Notice of Allowance dated Oct. 5, 2020, U.S. Appl. No. 16/682,911, (27 pages).
Notice of Reason of Refusal dated Sep. 11, 2020 with English translation, Japanese Patent Application No. 2019-140435, (6 pages).
"Phototourism Challenge", CVPR 2019 Image Matching Workshop. https://image matching-workshop. github.io., (16 pages).
Summons to attend oral proceedings pursuant to Rule 115(1) EPC mailed on Jul. 15, 2019, European Patent Application No. 15162521.7, (7 pages).
Aarik, J. et al., "Effect of crystal structure on optical properties of TiO2 films grown by atomic layer deposition", Thin Solid Films; Publication [online]. May 19, 1998 [retrieved Feb. 19, 2020], Retrieved from the Internet: <URL: https://www.sciencedirect.com/science/article/pii/S0040609097001351?via%3Dihub>; DOI: 10.1016/S0040-6090(97)00135-1; see entire document, (2 pages).
Arandjelović, Relja et al., "Three things everyone should know to improve object retrieval", CVPR, 2012, (8 pages).

(56)                **References Cited**

OTHER PUBLICATIONS

AZOM, , "Silica—Silicon Dioxide (SiO2)", AZO Materials; Publication [Online], Dec. 13, 2001 [retrieved Feb. 19, 2020], Retrieved from the Internet: <URL: https://www.azom.com/article.aspx? Article1D=1114>, (6 pages).

Azuma, Ronald T. , "A Survey of Augmented Reality", Presence: Teleoperators and Virtual Environments 6, 4 (Aug. 1997), 355-385; https://web.archive.org/web/20010604100006/http://www.cs.unc. edu/~azuma/ARpresence.pdf (downloaded Oct. 26, 2020).

Azuma, Ronald T. , "Predictive Tracking for Augmented Reality", Department of Computer Science, Chapel Hill NC; TR95-007, Feb. 1995, 262 pages.

Battaglia, Peter W. et al., "Relational inductive biases, deep learning, and graph networks", arXiv:1806.01261, Oct. 17, 2018, pp. 1-40.

Berg, Alexander C et al., "Shape matching and object recognition using low distortion correspondences", In CVPR, 2005, (8 pages).

Bian, Jiawang et al., "GMS: Grid-based motion statistics for fast, ultra-robust feature correspondence.", In CVPR (Conference on Computer Vision and Pattern Recognition), 2017, (10 pages).

Brachmann, Eric et al., "Neural-Guided RANSAC: Learning Where to Sample Model Hypotheses", In ICCV (International Conference on Computer Vision ), arXiv:1905.04132v2 [cs.CV] Jul. 31, 2019, (17 pages).

Butail, et al., "Putting the fish in the fish tank: Immersive VR for animal behavior experiments", In: 2012 IEEE International Conference on Robotics and Automation. May 18, 2012 (May 18, 2012) Retrieved on Nov. 14, 2020 (Nov. 14, 2020) from <http:/lcdcl.umd. edu/papers/icra2012.pdf> entire document, (8 pages).

Caetano, Tibério S et al., "Learning graph matching", IEEE TPAMI, 31(6):1048-1058, 2009.

Cech, Jan et al., "Efficient sequential correspondence selection by cosegmentation", IEEE TPAMI, 32(9):1568-1581, Sep. 2010.

Cuturi, Marco , "Sinkhorn distances: Lightspeed computation of optimal transport", NIPS, 2013, (9 pages).

Dai, Angela et al., "ScanNet: Richly-annotated 3d reconstructions of indoor scenes", In CVPR, arXiv:1702.04405v2 [cs.CV] Apr. 11, 2017, (22 pages).

Deng, Haowen et al., "PPFnet: Global context aware local features for robust 3d point matching", In CVPR, arXiv:1802.02669v2 [cs.CV] Mar. 1, 2018, (12 pages).

Detone, Daniel et al., "Deep image homography estimation", In RSS Work—shop: Limits and Potentials of Deep Learning in Robotics, arXiv:1606.03798v1 [cs.CV] Jun. 13, 2016, (6 pages).

Detone, Daniel et al., "Self-improving visual odometry", arXiv:1812. 03245, Dec. 8, 2018, (9 pages).

Detone, Daniel et al., "SuperPoint: Self-supervised interest point detection and description", In CVPR Workshop on Deep Learning for Visual SLAM, arXiv:1712.07629v4 [cs.CV] Apr. 19, 2018, (13 pages).

Dusmanu, Mihai et al., "D2-net: A trainable CNN for joint detection and description of local features", CVPR, arXiv:1905.03561v1 [cs.CV] May 9, 2019, (16 pages).

Ebel, Patrick et al., "Beyond cartesian representations for local descriptors", ICCV, arXiv:1908.05547v1 [cs.CV] Aug. 15, 2019, (11 pages).

Fischler, Martin A et al., "Random sample consensus: a paradigm for model fitting with applications to image analysis and automated cartography", Communications of the ACM, 24(6): 1981, pp. 381-395.

Gilmer, Justin et al., "Neural message passing for quantum chemistry", In ICML, arXiv:1704.01212v2 [cs.LG] Jun. 12, 2017, (14 pages).

Goodfellow, , "Titanium Dioxide—Titania (TiO2)", AZO Materials; Publication [online], Jan. 11, 2002 [retrieved Feb. 19, 2020]. Retrieved from the Internet: <URL: https://www.azom.com/article. aspx?Article1D=1179>, (9 pages).

Hartley, Richard et al., "Multiple View Geometry in Computer Vision", Cambridge University Press, 2003, pp. 1-673.

Jacob, Robert J. , "Eye Tracking in Advanced Interface Design", Human-Computer Interaction Lab, Naval Research Laboratory, Washington, D.C., date unknown. 2003, pp. 1-50.

Lee, Juho et al., "Set transformer: A frame-work for attention-based permutation-invariant neural networks", ICML, arXiv:1810. 00825v3 [cs.LG] May 26, 2019, (17 pages).

Leordeanu, Marius et al., "A spectral technique for correspondence problems using pairwise constraints", Proceedings of (ICCV) International Conference on Computer Vision, vol. 2, pp. 1482-1489, Oct. 2005, (8 pages).

Levola, T. , "Diffractive Optics for Virtual Reality Displays", Journal of the SID Eurodisplay 14/05, 2005, XP008093627, chapters 2-3, Figures 2 and 10, pp. 467-475.

Levola, Tapani , "Invited Paper: Novel Diffractive Optical Components for Near to Eye Displays—Nokia Research Center", SID 2006 DIGEST, 2006 SID International Symposium, Society for Information Display, vol. XXXVII, May 24, 2005, chapters 1-3, figures 1 and 3, pp. 64-67.

Li, Yujia et al., "Graph matching networks for learning the similarity of graph structured objects", ICML, arXiv:1904.12787v2 [cs.LG] May 12, 2019, (18 pages).

Li, Zhengqi et al., "Megadepth: Learning single-view depth prediction from internet photos", In CVPR, fromarXiv: 1804.00607v4 [cs.CV] Nov. 28, 2018, (10 pages).

Loiola, Eliane M. et al., "A survey for the quadratic assignment problem", European journal of operational research, 176(2): 2007, pp. 657-690.

Lowe, David G. , "Distinctive image features from scale-invariant keypoints", International Journal of Computer Vision, 60(2): 91-110, 2004, (28 pages).

Luo, Zixin et al., "ContextDesc: Local descriptor augmentation with cross-modality context", CVPR, arXiv:1904.04084v1 [cs.CV] Apr. 8, 2019, (14 pages).

Memon, F. et al., "Synthesis, Characterization and Optical Constants of Silicon Oxycarbide", EPJ Web of Conferences; Publication [online]. Mar. 23, 2017 [retrieved Feb. 19, 2020).<URL: https:// www.epj-conferences.org/articles/epjconf/pdf/2017/08/epjconf_ nanop2017_00002.pdf>; DOI: 10.1051/epjconf/201713900002, (8 pages).

Munkres, James , "Algorithms for the assignment and transportation problems", Journal of the Society for Industrial and Applied Mathematics, 5(1): 1957, pp. 32-38.

Ono, Yuki et al., "LF-Net: Learning local features from images", 32nd Conference on Neural Information Processing Systems (NIPS 2018), arXiv:1805.09662v2 [cs.CV] Nov. 22, 2018, (13 pages).

Paszke, Adam et al., "Automatic differentiation in Pytorch", 31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA, (4 pages).

Peyré, Gabriel et al., "Computational Optimal Transport", Foundations and Trends in Machine Learning, 11(5-6):355-607, 2019; arXiv:1803.00567v4 [stat.ML] Mar. 18, 2020, (209 pages).

Qi, Charles R. et al., "Pointnet++: Deep hierarchical feature learning on point sets in a metric space.", 31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA., (10 pages).

Qi, Charles R. et al., "Pointnet: Deep Learning on Point Sets for 3D Classification and Segmentation", CVPR, arXiv:1612.00593v2 [cs. CV] 10 Apr. 201, (19 pages).

Radenović, Filip et al., "Revisiting Oxford and Paris: Large-Scale Image Retrieval Benchmarking", CVPR, arXiv:1803.11285v1 [cs. CV] Mar. 29, 2018, (10 pages).

Raguram, Rahul et al., "A comparative analysis of ransac techniques leading to adaptive real-time random sample consensus", Computer Vision—ECCV 2008, 10th European Conference on Computer Vision, Marseille, France, Oct. 12-18, 2008, Proceedings, Part I, (15 pages).

Ranftl, René et al., "Deep fundamental matrix estimation", European Conference on Computer Vision (ECCV), 2018, (17 pages).

Revaud, Jerome et al., "R2D2: Repeatable and Reliable Detector and Descriptor", In NeurIPS, arXiv:1906.06195v2 [cs.CV] Jun. 17, 2019, (12 pages).

(56) **References Cited**

OTHER PUBLICATIONS

Rocco, Ignacio et al., "Neighbourhood Consensus Networks", 32nd Conference on Neural Information Processing Systems (NeurIPS 2018), Montréal, Canada, arXiv:1810.10510v2 [cs.CV] Nov. 29, 2018, (20 pages).

Rublee, Ethan et al., "ORB: An efficient alternative to SIFT or SURF", Proceedings of the IEEE International Conference on Computer Vision. 2564-2571. 2011; 10.1109/ICCV.2011.612654, (9 pages).

Sattler, Torsten et al., "SCRAMSAC: Improving RANSAC's efficiency with a spatial consistency filter", ICCV, 2009: 2090-2097., (8 pages).

Schonberger, Johannes L. et al., "Structure-from-motion revisited", Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 4104-4113, (11 pages).

Sinkhorn, Richard et al., "Concerning nonnegative matrices and doubly stochastic matrices.", Pacific Journal of Mathematics, 1967, pp. 343-348.

Spencer, T. et al., "Decomposition of poly(propylene carbonate) with UV sensitive iodonium 11 salts", Polymer Degradation and Stability; (online], Dec. 24, 2010 (retrieved Feb. 19, 2020]., <URL: http://fkohl.chbe.gatech.edu/sites/default/files/linked_files/publications/2011Decomposition%20of%20poly(propylene%20carbonate)%20with%20UV%20sensitive%20iodonium%20salts,pdf>; DOI: 10,1016/j.polymdegradstab.2010, 12.003, (17 pages).

Tanriverdi, Vildan et al., "Interacting With Eye Movements in Virtual Environments", Department of Electrical Engineering and Computer Science, Tufts University; Proceedings of the SIGCHI conference on Human Factors in Computing Systems, Apr. 2000, pp. 1-8.

Thomee, Bart et al., "YFCC100m: The new data in multimedia research", Communications of the ACM, 59(2):64-73, 2016; arXiv:1503.01817v2 [cs.MM] Apr. 25, 2016, (8 pages).

Torresani, Lorenzo et al., "Feature correspondence via graph matching: Models and global optimization", Computer Vision—ECCV 2008, 10th European Conference on Computer Vision, Marseille, France, Oct. 12-18, 2008, Proceedings, Part II, (15 pages).

Tuytelaars, Tinne et al., "Wide baseline stereo matching based on local, affinely invariant regions", BMVC, 2000, pp. 1-14.

Ulyanov, Dmitry et al., "Instance normalization: The missing ingredient for fast stylization", arXiv:1607.08022v3 [cs.CV] Nov. 6, 2017, (6 pages).

Vaswani, Ashish et al., "Attention is all you need", 31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA; arXiv:1706.03762v5 [cs.CL] Dec. 6, 2017, (15 pages).

Veličković, Petar et al., "Graph attention networks", ICLR, arXiv:1710.10903v3 [stat.ML] Feb. 4, 2018, (12 pages).

Wang, Yue et al., "Deep Closest Point: Learning representations for point cloud registration", ICCV, arXiv:1905.03304v1 [cs.CV] May 8, 2019, (10 pages).

Wang, Yue et al., "Dynamic Graph CNN for learning on point clouds", ACM Transactions on Graphics, arXiv:1801.07829v2 [cs.CV] Jun. 11, 2019, (13 pages).

Weissel, et al., "Process cruise control: event-driven clock scaling for dynamic power management", Proceedings of the 2002 international conference on Compilers, architecture, and synthesis for embedded systems. Oct. 11, 2002 (Oct. 11, 2002) Retrieved on May 16, 2020 (May 16, 2020) from <URL: https://dl.acm.org/doi/pdf/10.1145/581630.581668>, p. 238-246.

Yi, Kwang M. et al., "Learning to find good correspondences", CVPR, arXiv:1711.05971v2 [cs.CV] May 21, 2018, (13 pages).

Yi, Kwang Moo et al., "Lift: Learned invariant feature transform", ECCV, arXiv:1603.09114v2 [cs.CV] Jul. 29, 2016, (16 pages).

Zaheer, Manzil et al., "Deep Sets", 31st Conference on Neural Information Processing Systems (NIPS 2017), Long Beach, CA, USA arXiv:1703.06114v3 [cs.LG] Apr. 14, 2018, (29 pages).

Zhang, Jiahui et al., "Learning two-view correspondences and geometry using order-aware network", ICCV; aarXiv:1908.04964v1 [cs.CV] Aug. 14, 2019, (11 pages).

Zhang, Li et al., "Dual graph convolutional net-work for semantic segmentation", BMVC, 2019; arXiv:1909.06121v3 [cs.CV] Aug. 26, 2020, (18 pages).

Extended European Search Report dated Jan. 22, 2021, European Patent Application No. 18890390.0, (11 pages).

Extended European Search Report dated Mar. 4, 2021, European Patent Application No. 19768418.6, (9 pages).

Final Office Action dated Jun. 15, 2021, United States U.S. Appl. No. 16/928,313, (42 pages).

Final Office Action dated Mar. 1, 2021, U.S. Appl. No. 16/214,575, (29 pages).

Final Office Action dated Mar. 19, 2021, U.S. Appl. No. 16/530,776, (25 pages).

International Search Report and Written Opinion dated Feb. 12, 2021, International Application No. PCT/US20/60555, (25 pages).

International Search Report and Written Opinion dated Feb. 2, 2021, International PCT Patent Application No. PCT/US20/60550, (9 pages).

Non Final Office Action dated Jan. 26, 2021, U.S. Appl. No. 16/928,313, (33 pages).

Non Final Office Action dated Jan. 27, 2021, U.S. Appl. No. 16/225,961, (15 pages).

Non Final Office Action dated Jun. 10, 2021, U.S. Appl. No. 16/938,782, (40 Pages).

Non Final Office Action dated Mar. 3, 2021, U.S. Appl. No. 16/427,337, (41 pages).

Non Final Office Action dated May 26, 2021, U.S. Appl. No. 16/214,575, (19 pages).

Altwaijry, et al., "Learning to Detect and Match Keypoints with Deep Architectures", Proceedings of the British Machine Vision Conference (BMVC), BMVA Press, Sep. 2016, [retrieved on Jan. 8, 2021 (Jan. 8, 2021 )] < URL: http://www.bmva.org/bmvc/2016/papers/paper049/index.html >, en lire document, especially Abstract, pp. 1-6 and 9.

Lee, et al., "Self-Attention Graph Pooling", Cornell University Library/Computer Science/ Machine Learning, Apr. 17, 2019 [retrieved on Jan. 8, 2021 from the Internet< URL: https://arxiv.org/abs/1904.08082 >, entire document.

Libovicky, et al., "Input Combination Strategies for Multi-Source Transformer Decoder", Proceedings of the Third Conference on Machine Translation (WMT). vol. 1: Research Papers, Belgium, Brussels, Oct. 31-Nov. 1, 2018; retrieved on Jan. 8, 2021 (Jan. 8, 2021 ) from < URL: https://doi.org/10.18653/v1/W18-64026 >, entire document, pp. 253-260.

Molchanov, Pavlo et al., "Short-range FMCW monopulse radar for hand-gesture sensing", 2015 IEEE Radar Conference (RadarCon) (2015), pp. 1491-1496.

Sarlin, et al., "SuperGlue: Learning Feature Matching with Graph Neural Networks", Cornell University Library/Computer Science/ Computer Vision and Pattern Recognition, Nov. 26, 2019 [retrieved on Jan. 8, 2021 from the Internet< URL: https://arxiv.org/abs/1911.11763>, entire document.

Communication Pursuant to Article 94(3) EPC dated Apr. 25, 2022, European Patent Application No. 18885707.2, (5 pages).

Extended European Search Report dated Mar. 22, 2022, European Patent Application No. 19843487.0, (14 pages).

First Examination Report dated May 13, 2022, Indian Patent Application No. 202047026359, (8 pages).

First Office Action dated Mar. 14, 2022 with English translation, Chinese Patent Application No. 201880079474.6, (11 pages).

Non Final Office Action dated Apr. 1, 2022, U.S. Appl. No. 17/256,961, (65 pages).

Non Final Office Action dated Apr. 11, 2022, U.S. Appl. No. 16/938,782, (52 pages).

Non Final Office Action dated Apr. 12, 2022, U.S. Appl. No. 17/262,991, (60 pages).

Non Final Office Action dated Mar. 9, 2022, U.S. Appl. No. 16/870,676, (57 pages).

Non Final Office Action dated May 10, 2022, U.S. Appl. No. 17/140,921, (25 pages).

Non Final Office Action dated May 17, 2022, U.S. Appl. No. 16/748,193, (11 pages).

(56) **References Cited**

OTHER PUBLICATIONS

Extended European Search Report dated Jun. 19, 2020, European Patent Application No. 20154750.2, (10 pages).

Communication according to Rule 164(1) EPC dated Feb. 23, 2022, European Patent Application No. 20753144.3, (11 pages).

Communication Pursuant to Article 94(3) EPC dated Oct. 21, 2021, European Patent Application No. 16207441.3, (4 pages).

Communication Pursuant to Rule 164(1) EPC dated Jul. 27, 2021, European Patent Application No. 19833664.6, (11 pages).

Extended European Search Report dated Jun. 30, 2021, European Patent Application No. 19811971.1, (9 pages).

Extended European Search Report dated Jan. 28, 2022, European Patent Application No. 19815876.8, (9 pages).

Extended European Search Report dated Jan. 4, 2022, European Patent Application No. 19815085.6, (9 pages).

Extended European Search Report dated Jul. 16, 2021, European Patent Application No. 19810142.0, (14 pages).

Extended European Search Report dated Jul. 30, 2021, European Patent Application No. 19839970.1, (7 pages).

Extended European Search Report dated Oct. 27, 2021, European Patent Application No. 19833664.6, (10 pages).

Extended European Search Report dated Sep. 20, 2021, European Patent Application No. 19851373.1, (8 pages).

Extended European Search Report dated Sep. 28, 2021, European Patent Application No. 19845418.3, (13 pages).

Final Office Action dated Feb. 23, 2022, U.S. Appl. No. 16/748,193, (23 pages).

Final Office Action dated Feb. 3, 2022, United States U.S. Appl. No. 16/864,721, (36 pages).

Final Office Action dated Sep. 17, 2021, U.S. Appl. No. 16/938,782, (44 pages).

"Multi-core processor", TechTarget, 2013 , (1 page).

Non Final Office Action dated Aug. 4, 2021, U.S. Appl. No. 16/864,721, (51 pages).

Non Final Office Action dated Feb. 2, 2022, U.S. Appl. No. 16/783,866, (8 pages).

Non Final Office Action dated Jul. 9, 2021, U.S. Appl. No. 17/002,663, (43 pages).

Non Final Office Action dated Jul. 9, 2021, U.S. Appl. No. 16/833,093, (47 pages).

Non Final Office Action dated Jun. 29, 2021, U.S. Appl. No. 16/698,588, (58 pages).

Non Final Office Action dated Sep. 20, 2021, U.S. Appl. No. 17/105,848, (56 pages).

Non Final Office Action dated Sep. 29, 2021, U.S. Appl. No. 16/748,193, (62 pages).

Giuseppe, Donato , et al. , "Stereoscopic helmet mounted system for real time 3D environment reconstruction and indoor ego—motion estimation", Proc. SPIE 6955, Head- and Helmet-Mounted Displays XIII: Design and Applications, SPIE Defense and Security Symposium, 2008, Orlando, Florida, United States, 69550P.

MRAD , et al. , "A framework for System Level Low Power Design Space Exploration", 1991.

Sheng, Liu , et al. , "Time-multiplexed dual-focal plane head-mounted display with a liquid lens", Optics Letters, Optical Society of AMER I CA, US, vol. 34, No. 11, Jun. 1, 2009 (Jun. 1, 2009), XP001524475, ISSN: 0146-9592, pp. 1642-1644.

"Communication Pursuant to Article 94(3) EPC dated May 30, 2022", European Patent Application No. 19768418.6, (6 pages).

"Extended European Search Report dated May 16, 2022", European Patent Application No. 19871001.4, (9 pages).

"Extended European Search Report dated May 30, 2022", European Patent Application No. 20753144.3, (10 pages).

"Extended European Search Report dated Jul. 20, 2022", European Patent Application No. 19885958.9, (9 pages).

"Extended European Search Report dated Aug. 8, 2022", European Patent Application No. 19898874.3, (8 pages).

"First Examination Report dated Jul. 27, 2022", Chinese Patent Application No. 201980036675.2, (5 pages).

"First Examination Report dated Jul. 28, 2022", Indian Patent Application No. 202047024232, (6 pages).

"Non Final Office Action dated Jul. 26, 2022", U.S. Appl. No. 17/098,059, (28 pages).

"Second Office Action dated Jul. 13, 2022 with English Translation", Chinese Patent Application No. 201880079474.6, (10 pages).

Chittineni, C., et al., "Single filters for combined image geometric manipulation and enhancement", Proceedings of SPIE vol. 1903, Image and Video Processing, Apr. 8, 1993, San Jose, CA. (Year 1993), pp. 111-121.

"Extended European Search Report dated Aug. 24, 2022", European Patent Application No. 20846338.0, (13 pages).

"Final Office Action dated Jul. 13, 2022", U.S. Appl. No. 17/262,991, (18 pages).

"Non Final Office Action dated Sep. 19, 2022", U.S. Appl. No. 17/263,001, (14 pages).

"Second Office Action dated Jun. 20, 2022 with English Translation", Chinese Patent Application No. 201880089255.6, (14 pages).

Anonymous , "Koi Pond: Top iPhone App Store Paid App", https://web.archive.org/web/20080904061233/https://www.iphoneincanada.ca/reviews /koi-pond-top-iphone-app-store-paid-app/ - [retrieved on Aug. 9, 2022], (2 pages).
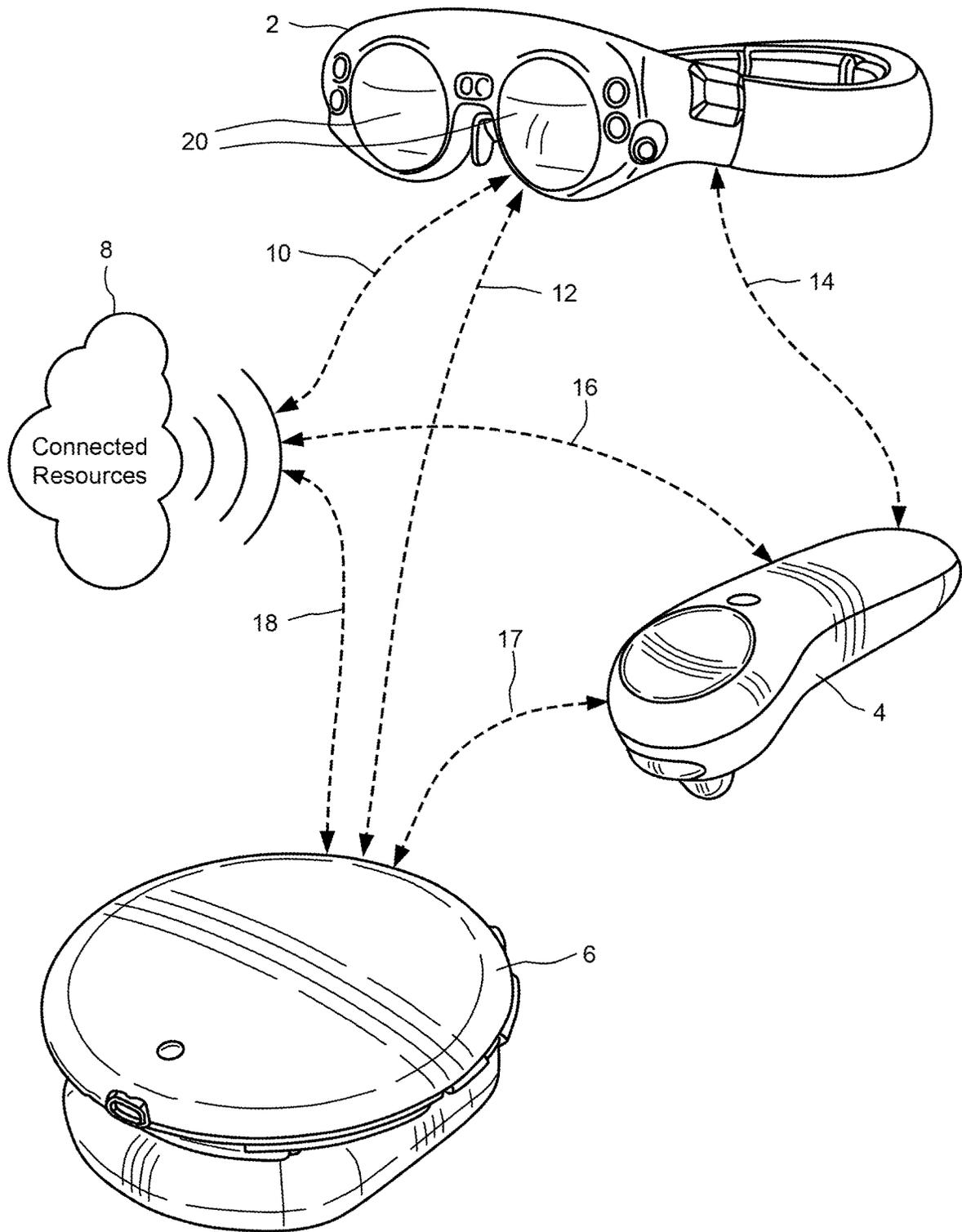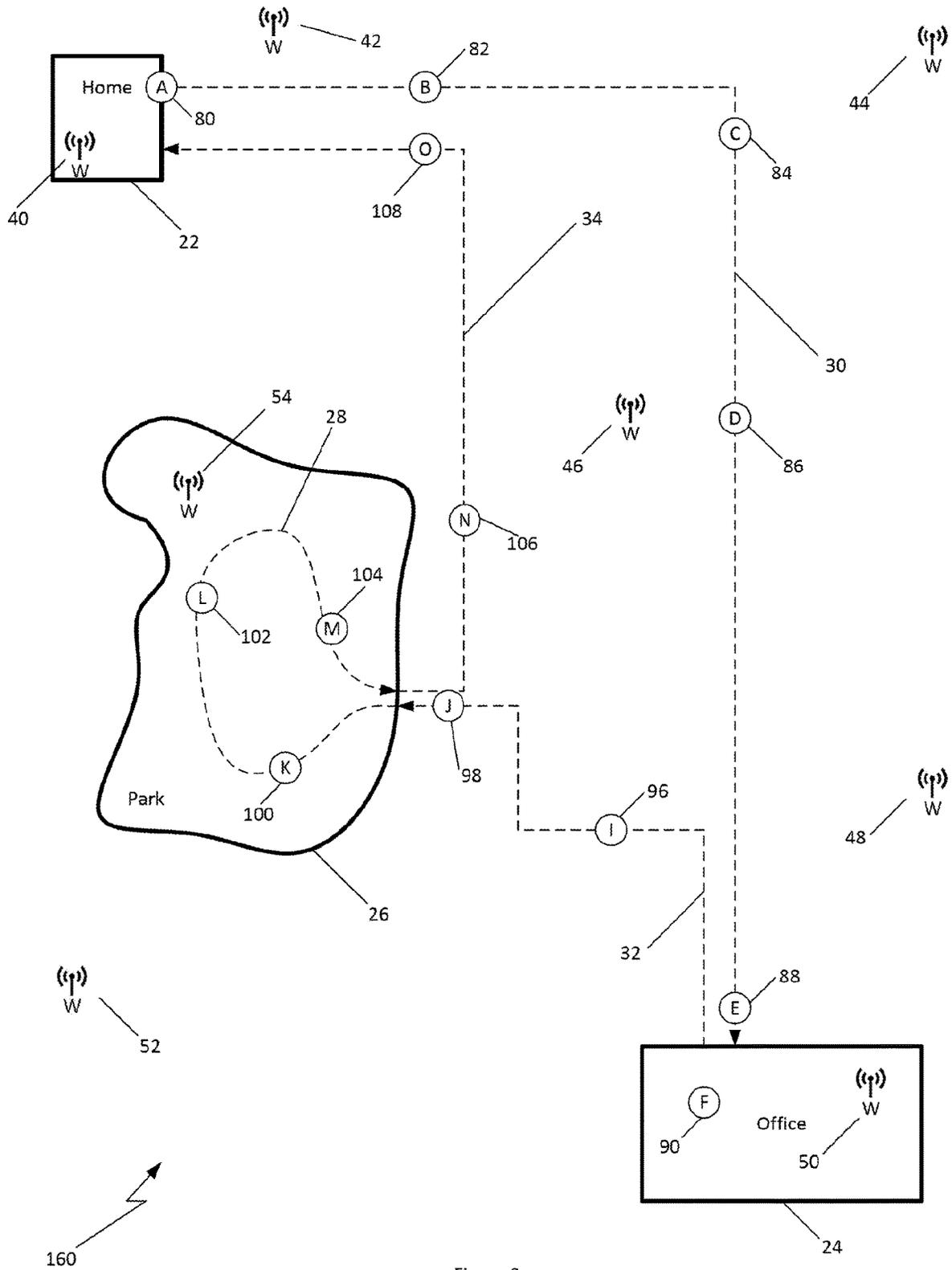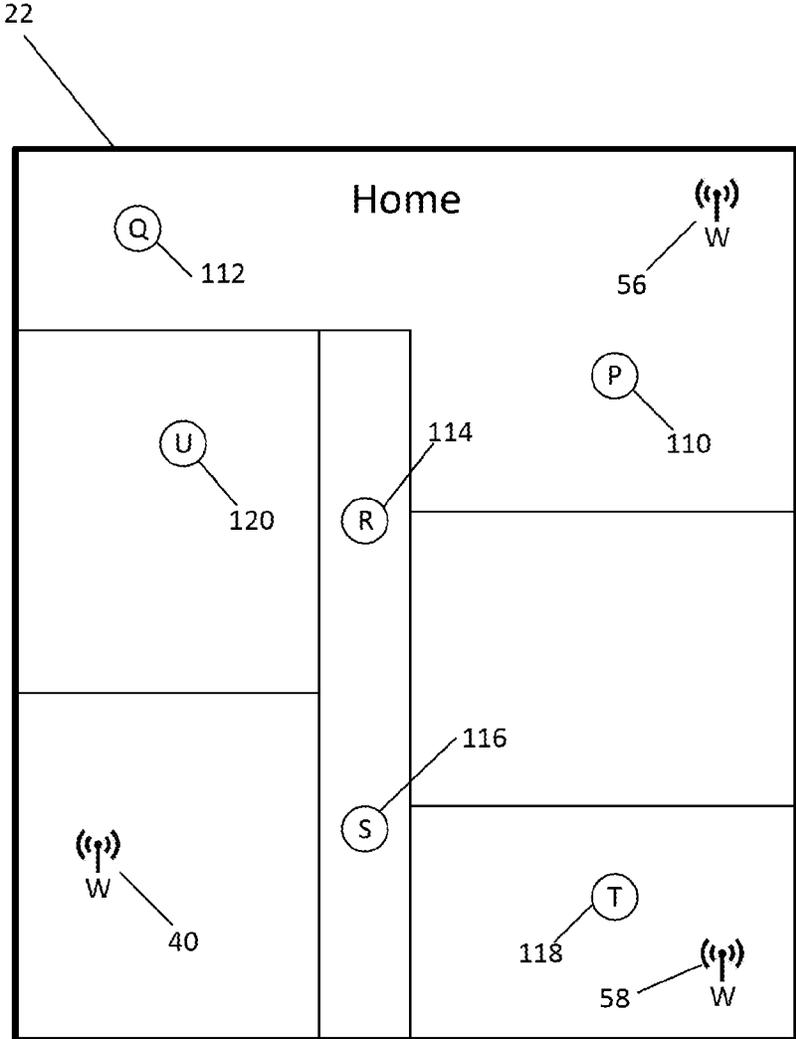
* cited by examiner

**Figure 1**

Figure 2

Figure 3

Figure 4

Figure 5

40

(((•)))

W

136

140

Storage

138

Controller        134

142

Power

132

Transceiver

130

144

Ext Storage
Resources        146

Ext Power
Resources        148

Ext Connectivity
Resources

150

Figure 6

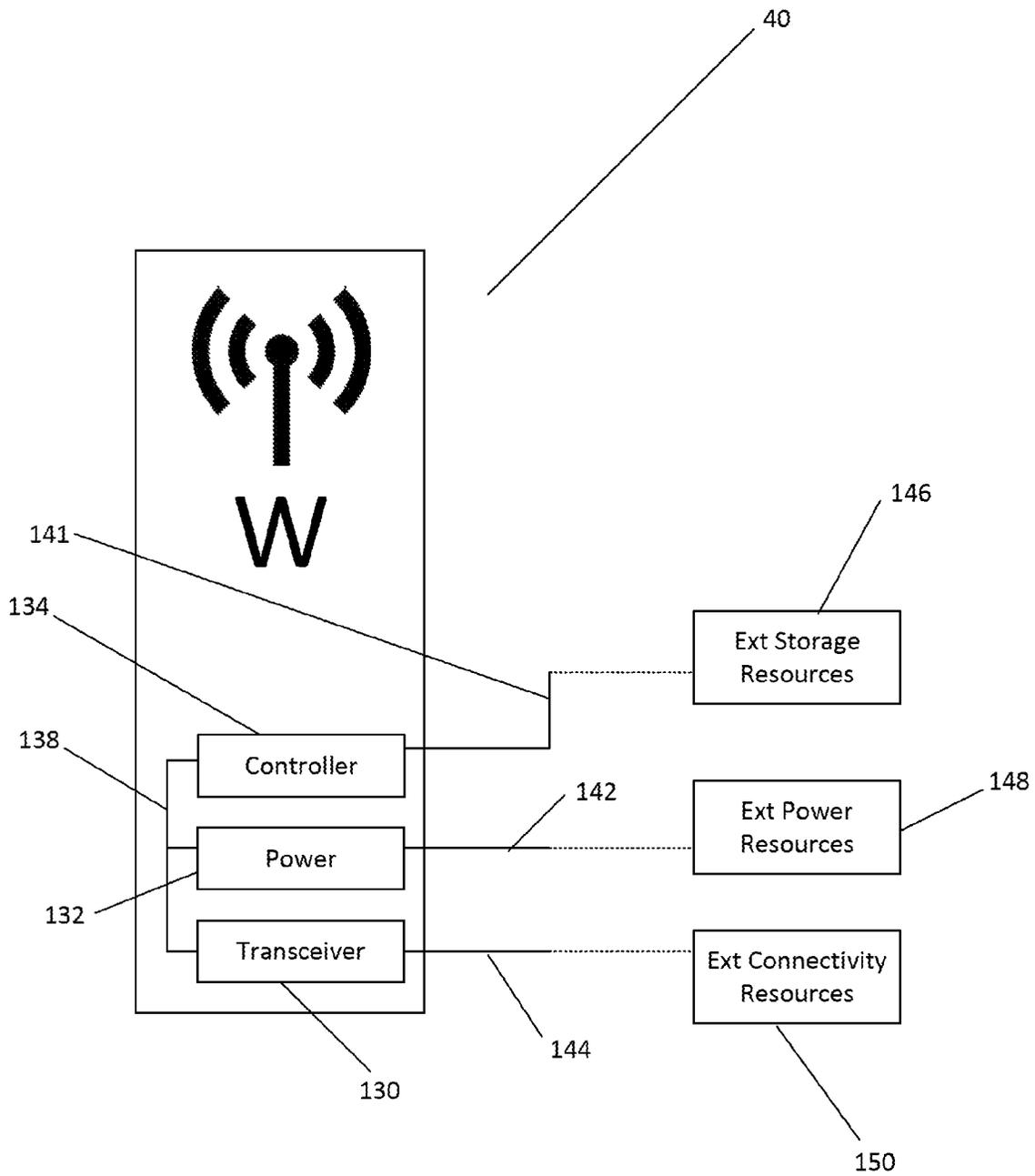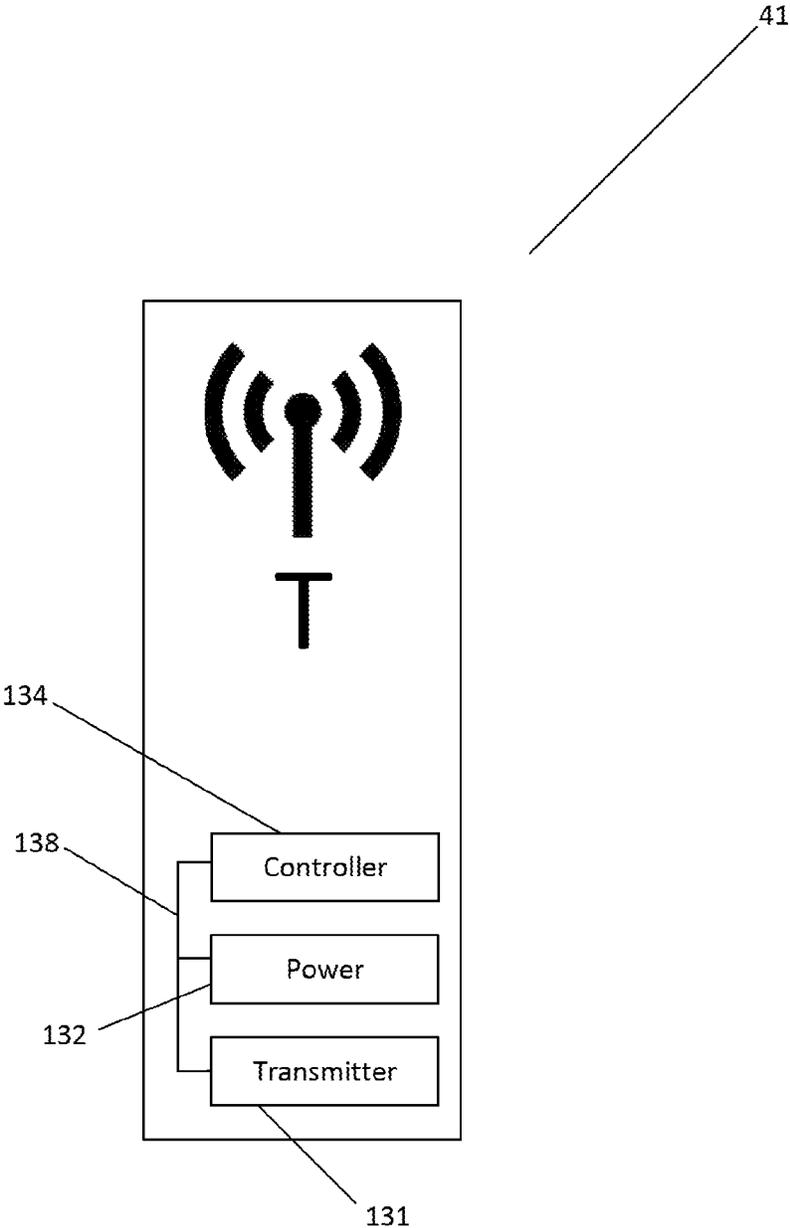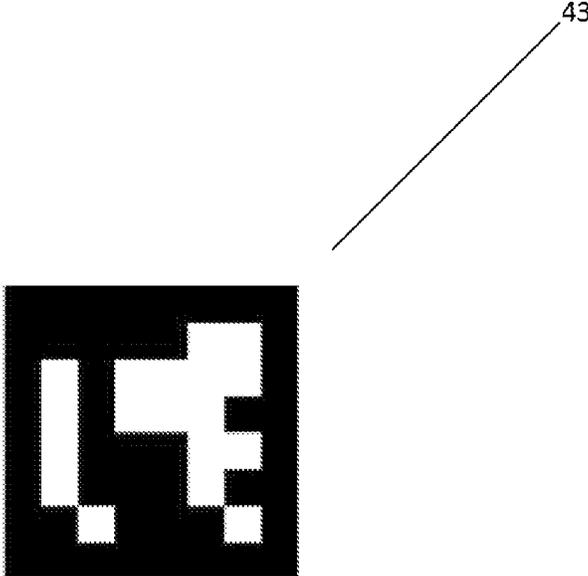Figure 7

41

134

138

132

| Controller |

| Power |

| Transmitter |

131
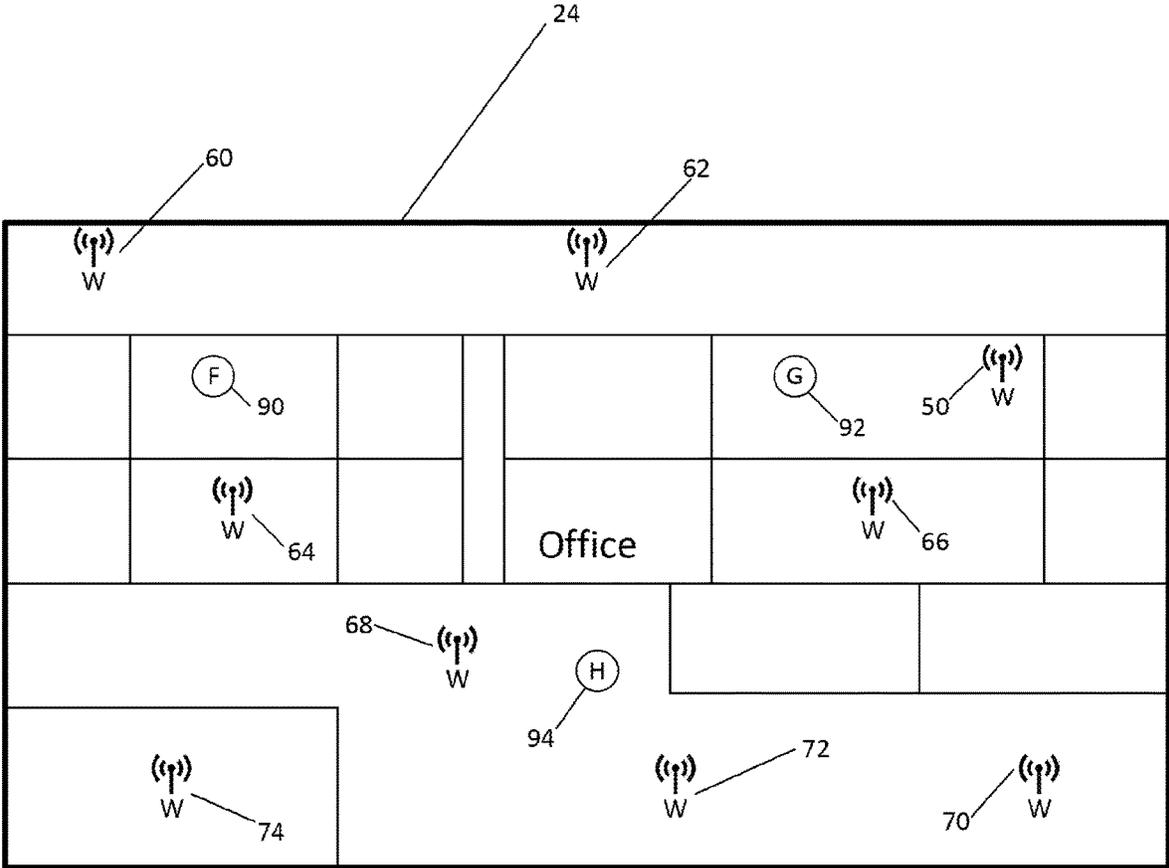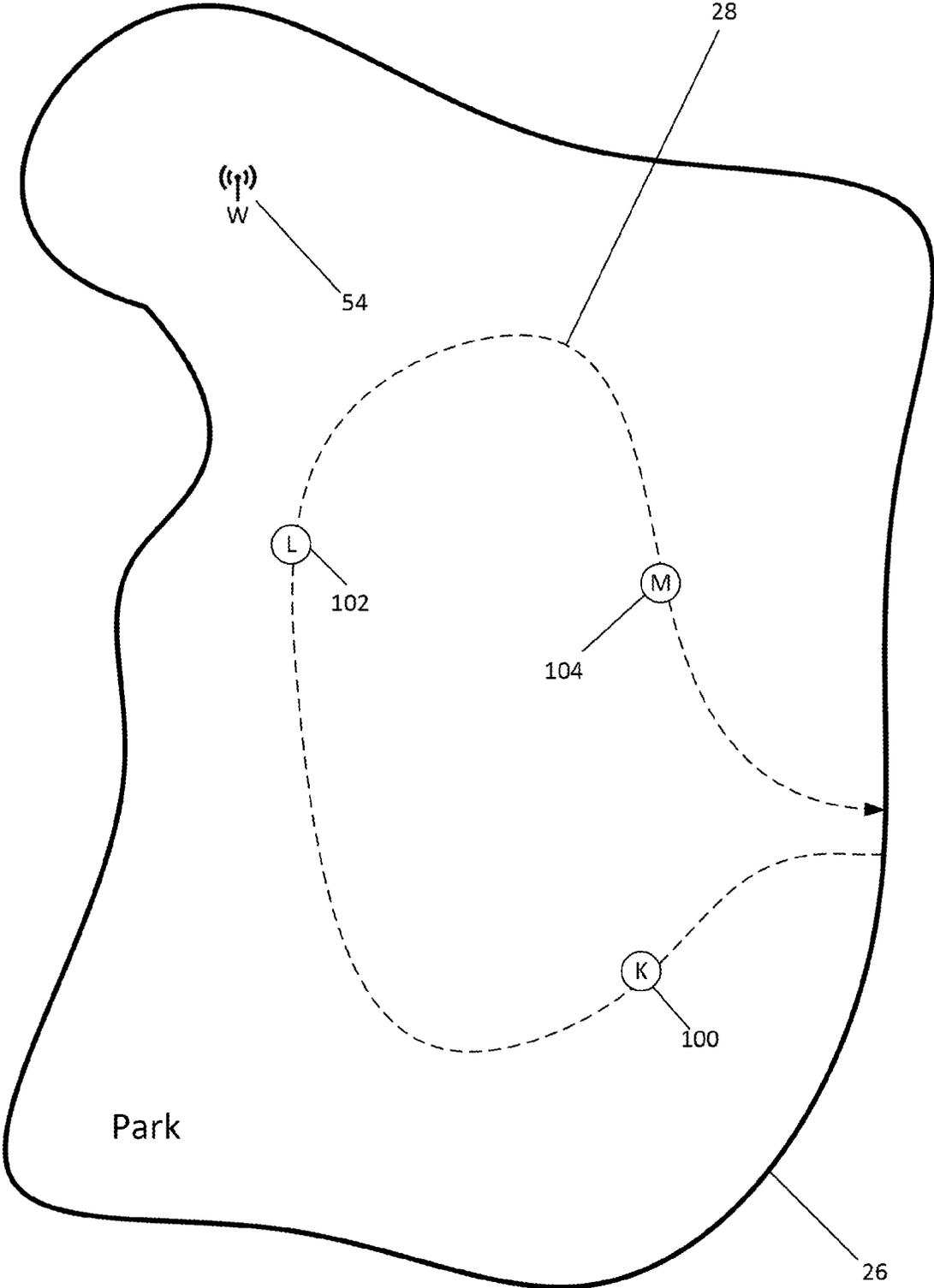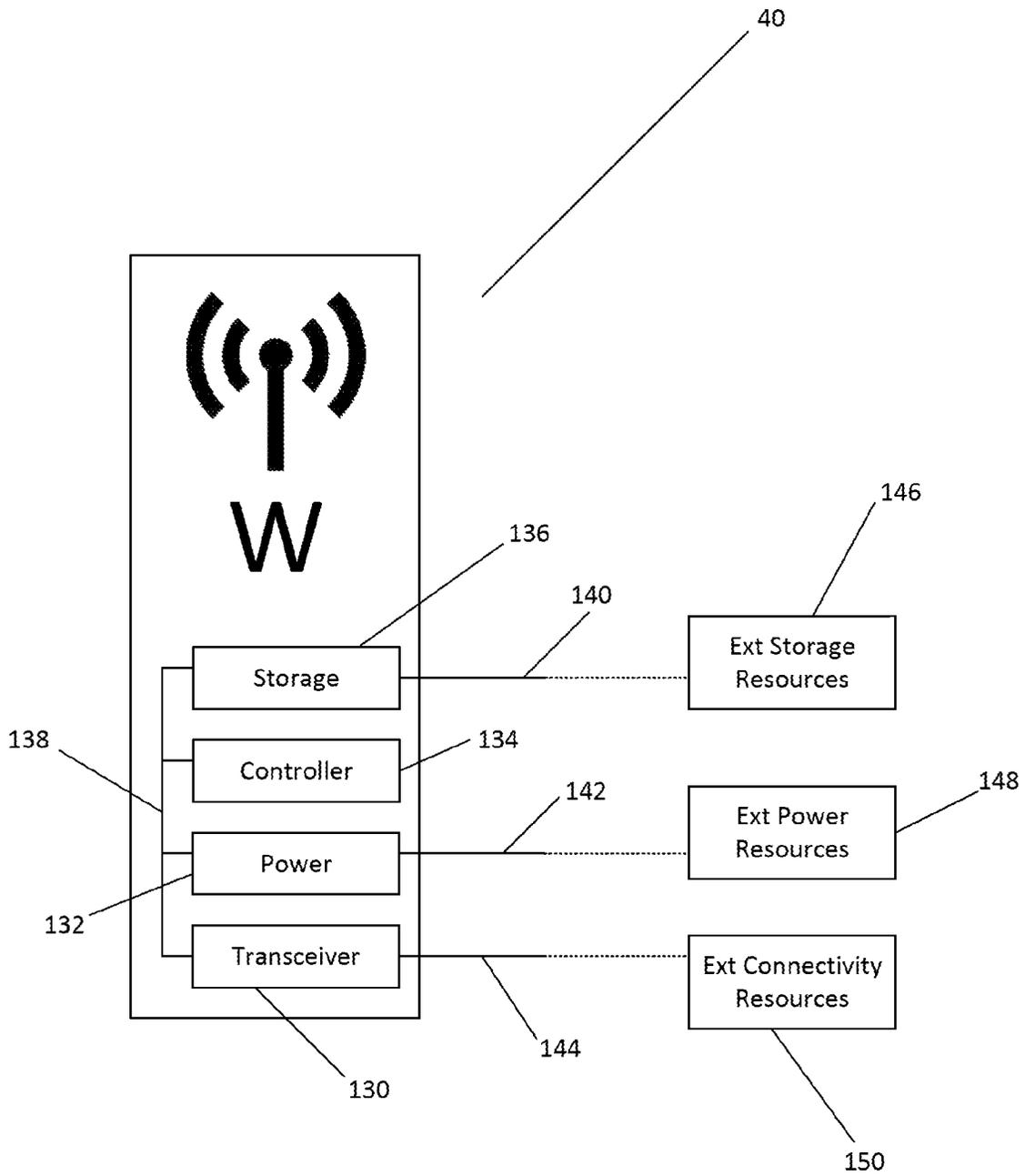
Figure 8

Figure 9

# SYSTEMS AND METHODS FOR VIRTUAL AND AUGMENTED REALITY

## CROSS-REFERENCE TO RELATED APPLICATION

This is a national phase of International Patent Application No: PCT/US2019/040544, filed on Jul. 3, 2019, which claims benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Ser. No. 62/693,891, titled "Systems and Methods for Virtual and Augmented Reality," which was filed on Jul. 3, 2018, all of which are incorporated herein by reference in their entirety.

## FIELD OF THE INVENTION

This invention is related to connected mobile computing systems, methods, and configurations, and more specifically to mobile computing systems, methods, and configurations featuring at least one wearable component which may be utilized for virtual and/or augmented reality operation.

## BACKGROUND

It is desirable that mixed reality, or augmented reality, near-eye displays be lightweight, low-cost, have a small form-factor, have a wide virtual image field of view, and be as transparent as possible. In addition, it is desirable to have configurations that present virtual image information in multiple focal planes (for example, two or more) in order to be practical for a wide variety of use-cases without exceeding an acceptable allowance for vergence-accommodation mismatch. Referring to FIG. 1, an augmented reality system is illustrated featuring a head-worn viewing component (2), a hand-held controller component (4), and an interconnected auxiliary computing or controller component (6) which may be configured to be worn as a belt pack or the like on the user. Each of these components may be operatively coupled (10, 12, 14, 16, 17, 18) to each other and to other connected resources (8) such as cloud computing or cloud storage resources via wired or wireless communication configurations, such as those specified by IEEE 802.11, Bluetooth®, and other connectivity standards and configurations. The augmented reality system can include the two depicted optical elements (20) through which the user may see the world around them along with visual components which may be produced by the associated system components, for an augmented reality experience. There is a need for compact and persistently connected systems and assemblies which are optimized for use in wearable computing systems.

## SUMMARY

The present disclosure is generally directed to presenting information through a display of a mobile computing system. More specifically, the present disclosure describes, according to various embodiments, receiving information that is wirelessly transmitted to the mobile computing system by wireless devices that are proximal to a route being travelled by the mobile computing system, and presenting at least a portion of the received information through a display of the mobile computing system according to a computing experience determined for a user of the mobile computing system.

Embodiments of the present disclosure include a method performed by the mobile computing system, the method including the following operations: determining a comput-

ing experience for a user of the mobile computing system; establishing a wireless connection between the mobile computing system and each of a plurality of wireless devices, wherein each respective wireless device is in proximity to a travel route of the mobile computing system; receiving, over each respective wireless connection between the mobile computing system and a respective wireless device, location-based information that is associated with a location of the respective wireless device in proximity to the travel route; and presenting, through a display of the mobile computing system, the location-based information received from each of the plurality of wireless devices, wherein the location-based information is presented according to the determined computing experience.

Embodiments of the present disclosure can also optionally include one or more of the following aspects: determining the computing experience includes receiving a selection of the computing experience that is made by the user through the mobile computing system; determining the computing experience includes accessing at least one data source that stores a schedule of the user, and inferring the computing experience based at least partly on the schedule of the user; at least two of the plurality of wireless devices are at different locations in proximity to the travel route; the respective location-based information received from each of the at least two wireless devices is presented, through the display, during different periods of time; the computing experience includes at least one regulation that indicates at least: i) a first type of content to be displayed while the computing experience is employed, and ii) a second type of content to not be displayed while the computing experience is employed; presenting the location-based information includes presenting the first type of content and not presenting the second type of content; at least a portion of the location-based information that is associated with the location of the respective wireless device is stored locally on the respective wireless device; the mobile computing system is a wearable computing device; at least a portion of the location-based information that is associated with the location of the respective wireless device is communicated to the mobile computing system responsive to the mobile computing system scanning a beacon that is proximal to the location; at least the portion of the location-based information is communicated to the mobile computing system from a cloud-based storage system; the display of the mobile computing system is an augmented reality display or a mixed reality display; the location-based information sent from the respective wireless device includes geometric information associated with a feature in proximity to the location of the respective wireless device; and/or presenting the location-based information includes using the geometric information to present a virtual representation of the feature in the display.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an example computing system.

FIGS. 2-5 show example environments in which a mobile computing system can operate according to embodiments of the present disclosure.

FIG. 6-8 show schematics of example wireless devices according to embodiments of the present disclosure.

FIG. 9 shows an example marker which can be employed according to embodiments of the present disclosure.

## DETAILED DESCRIPTION

Referring to FIG. 2, a travelling scenario (160) is depicted wherein a user of a mobile computing system, such as the

wearable computing system described in reference to FIG. 1, operates in the world. FIG. 2 illustrates a home (22) of the user which features at least one wireless device (40) configured to connect the user's wearable computing system. As the user navigates the world around him, here in an illustrative example day wherein the user travels (30) from home (22; point A—80) to work (24; points B—82, C—84, D—86, E—88); then from work (24) he travels (32; points I—96, J—98) to a park (26) for a walk (28; points K—100, L—102, M—104) before the rest of the return (34; points N—106, O—108) to home (22)—along the way coming into wireless contact between his mobile computing system and various wireless devices (40, 42, 44, 46, 48, 50, 52, 54, and others as shown in magnified views of FIG. 3 and FIG. 4). Preferably the mobile computing system is configured to utilize various wireless devices and information exchanged therewith to provide the user with a relatively low-latency and robust connectivity experience, generally subject to user preferences which may be selected by the user.

In some embodiments, the mobile computing system can be an augmented reality, or mixed reality, system as described, for example, in U.S. patent application Ser. Nos. 14/555,585, 14/690,401, 14/331,218, 15/481,255, and 62/518,539, each of which is incorporated by reference herein in its entirety.

In one embodiment, the mobile computing system may be configured such that the user selects certain aspects of his computing experience for the day. For example, through a graphical user interface, voice controls, and/or gestures, the user may input to the mobile computing system that he'll have a typical work day, usual route there, stopping at park for brief walk on the way home. Preferably the mobile computing system has certain artificial intelligence aspects so that it may use integration with his electronic calendar to provisionally understand his schedule, subject to quick confirmations. For example, as he is departing for work, the system may be configured to say or show: "headed to work; usual route and usual computing configuration", and this usual route may be garnered from previous GPS and/or mobile triangulation data through his mobile computing system. The "usual computing configuration" may be customized by the user and subject to regulations; for example, the system may be configured to only present certain non-occlusive visuals, no advertisements, and no shopping or other information not pertinent to driving while the user is driving, and to provide an audio version of a news program or current favorite audiobook while the user is driving on his way to work. As the user navigates the drive on the way to work, he may leave connectivity with his home wireless device (40) and enter or maintain connectivity with other wireless devices (42, 44, 46, 48). Each of these wireless devices may be configured to provide the user's mobile computing system with information pertinent to the user's experience at relatively low latency (e.g., by storing locally certain information which may be pertinent to the user at that location). FIGS. 6 and 7 illustrate certain aspects of wireless devices which may be utilized as described herein; the embodiments of FIGS. 8 and 9 feature non-storage beacon and/or marker configurations which also may be utilized to connect directly to locally-pertinent cloud-based information without the benefit of local storage.

For example, as the user travels from point A (80) to point B (82) to point C (84), a local wireless device (44) around point C (84) may be configured to pass to the user's mobile system geometric information which may be utilized on the user's mobile computing system for highlighting where a trench is being created at such location, so that the user

clearly visualizes and/or understands the hazard while driving past, and this geometric information (which may feature a highlighted outline of the trench, for example; may also feature one or more photos or other non-geometric information) maybe locally stored on the local wireless device (44) so that it does not need to be pulled from more remote resources which may involve greater latency in getting the information to the driver. In addition to lowering latency, local storage also may function to decrease the overall compute load on the user's mobile computing system, because the mobile system may receive information that it otherwise would have had to generate or build itself based upon sensors, for example, which may comprise part of the locally mobile hardware.

Once the user arrives at the parking lot of his work (24), the system may, for example, be configured to detect walking velocity and to be configured by the user to review with the user his schedule for the day, via an integration with his computerized calendaring system, as he is walking up to the office. Certain additional information not resident on his locally mobile computing system may be pulled from local sources (48, 50, for example) which may feature certain storage capacity, to again facilitate smaller mobile overhead and lower latency versus direct cloud connectivity.

Referring to FIG. 4, once in the office (24), the user may connect with a variety of wireless devices (50, 60, 62, 64, 66, 68, 70, 72, 74), each of which may be configured to be able to provide location-based information. For example, when at point F (90), the user's mobile computing system may be configured to detect the location (such as by GPS, computer vision, marker or beacon identification, and/or wireless device (60, 62, 64) triangulation) and then quickly upload from local storage (e.g., from a wireless device 60, 62, 64) to his mobile computing system information pertinent to that location, such as a dense triangular mesh of the geometry of the room, or certain information pertaining to whose office that room is, information about that person, or other information that may be deemed relevant, such as by an artificial intelligence agent working automatically on the user's mobile computing system. Various other wireless devices (50, 66, 68, 70, 72, 74) may be positioned in other locations of the office and configured to feature other location-based information, again to provide local users with low-latency and robust mobile computing functionality without everything, such as determination of the room geometry, being done de novo by the sensor facilities local to the mobile computing system in real time. Referring to FIG. 3, similar wireless device resources (40, 56, 58) may be utilized in the home (22) to assist with location-based information as the user navigates (P—110, Q—112, R—114, S—116, T—118, U—120) the home with his mobile computing system. In the office (24) or home (22) environments, the mobile computing system may be configured to utilize external resources quite differently from driving. For example, the artificial intelligence component of the user's mobile computing system may be aware that the user likes to watch nightly news highlights from the previous week (perhaps in a display manner that would ordinarily not be acceptable when driving, but is acceptable when walking, or perhaps automatically expanding when the user stops walking around and is seated or standing mobile) as he is walking around on Saturday mornings between 7 and 8 am, and so when walking velocity is detected, the system may be configured to deliver such highlights from local storage between those hours, while also gathering other location-based information such as the position of various objects or

structures within the house (e.g., to decrease computer vision processing load) in the pertinent location.

Similarly, as the user navigates a walk (**28**) through the park (**26**), shown in magnified view in FIG. **5**, local wireless device resources (**54**) may be utilized to provide location-based information, such as background information related to a sculpture garden that the user may be observing as he walks along; such information may be displayed or reproduced as audio as the user is walking around in a manner that is tailored and/or customizable to his walking-in-a-park scenario (e.g., as opposed to driving, or walking around in the home or work).

Referring to FIG. **6**, in one embodiment, one of more of the aforementioned wireless devices (**40, 42, 44, 46, 48, 50, 52, 54**, and others as shown in magnified views of FIG. **3** and FIG. **4**) may comprise a system as shown in FIG. **6**, wherein a local controller (**134**), such as a processor, is operatively coupled (**138**) to a power supply (**132**), such as a battery, a transceiver (**130**), such as a transmitting and receiving antenna set, and a local storage device (**136**), such as a mass storage or memory device. The storage device (**136**) may be operatively coupled (**140**) to external storage resources (**146**), such as cloud storage resources; the local power supply (**132**) may be operatively coupled (**142**) to external power resources (**148**), such as for long term charging or replenishment; the transceiver (**130**) may be operatively coupled to external connectivity resources (**150**) to provide access, for example, to the internet backbone. All of these local and connected resources may be configured based upon the location of such device, to provide local users with information tailored to the local scenario, whether such information is pertinent to traffic, shopping, weather, structures, culture, etc. FIG. **7** illustrates an embodiment similar to that of FIG. **6**, but without local storage facility—the components thereof are operatively coupled (**141**) to remote storage resources (**146**), such as cloud resources; such an embodiment as in FIG. **7** maybe utilized in various configurations in place of embodiments such as those in FIG. **6**, without the benefit of directly local storage (as described above, such local storage may be beneficial in reducing latency in terms of providing information to a mobile system in the area). Referring to FIG. **8**, in further scenarios without local storage capability, a transmitter beacon (**41**) type of device, for example featuring only a transmitter (**131**, not a two-way transceiver) and a relatively long-term battery (**132**), may be utilized to connect to a locally positioned mobile computing device to share location or beacon identification information the functions as a pointer to connect mobile computing system with pertinent cloud resources (e.g., bypassing local storage, but providing information akin to: you are here+pointers to cloud resources that are pertinent). Referring to FIG. **9**, in a very basic scenario, a non-electronic marker (**43**), such as an aruco marker, may be utilized to also function as a pointer to connect mobile computing system with pertinent cloud resources (e.g., bypassing local storage, but providing information akin to: you are here+pointers to cloud resources that are pertinent).

As described above, to decrease latency and generally increase useful access to pertinent location-based information, wireless devices with localized storage resources, such as those depicted in FIG. **6**, may be located throughout the interiors of structures such as homes, enterprises, etc.—and also exteriors, such as urban downtown areas, outsides of stores or shops, etc. Similarly, wireless devices without localized storage capacity—but operatively coupled to, or pointed to, remote storage resources, also may be located throughout the interiors of structures such as homes, enter-

prises, etc.—and also exteriors, such as urban downtown areas, outsides of stores or shops, etc.

In one embodiment, the mobile computing system may be customizable by the user to present information filtered on a time-domain basis, such as by how old or "stale" such information is. For example, the user may be able to configure the system to only provide traffic information while he is driving that is 10 minutes old or newer, etc. (e.g., the time domain aspect may be customized/configurable); or the user may be able to configure the system to only present architectural (e.g., position of walls within a building) that is one year old or newer etc. (e.g., the time domain aspect may be customized/configurable).

Various example embodiments of the invention are described herein. Reference is made to these examples in a non-limiting sense. They are provided to illustrate more broadly applicable aspects of the invention. Various changes may be made to the invention described and equivalents may be substituted without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation, material, composition of matter, process, process act(s) or step(s) to the objective(s), spirit or scope of the present invention. Further, as will be appreciated by those with skill in the art that each of the individual variations described and illustrated herein has discrete components and features which may be readily separated from or combined with the features of any of the other several embodiments without departing from the scope or spirit of the present inventions. All such modifications are intended to be within the scope of claims associated with this disclosure.

The invention includes methods that may be performed using the subject devices. The methods may comprise the act of providing such a suitable device. Such provision may be performed by the end user. In other words, the "providing" act merely requires the end user obtain, access, approach, position, set-up, activate, power-up or otherwise act to provide the requisite device in the subject method. Methods recited herein may be carried out in any order of the recited events which is logically possible, as well as in the recited order of events.

Example aspects of the invention, together with details regarding material selection and manufacture have been set forth above. As for other details of the present invention, these may be appreciated in connection with the above-referenced patents and publications as well as generally known or appreciated by those with skill in the art. The same may hold true with respect to method-based aspects of the invention in terms of additional acts as commonly or logically employed.

In addition, though the invention has been described in reference to several examples optionally incorporating various features, the invention is not to be limited to that which is described or indicated as contemplated with respect to each variation of the invention. Various changes may be made to the invention described and equivalents (whether recited herein or not included for the sake of some brevity) may be substituted without departing from the true spirit and scope of the invention. In addition, where a range of values is provided, it is understood that every intervening value, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the invention.

Also, it is contemplated that any optional feature of the inventive variations described may be set forth and claimed independently, or in combination with any one or more of the features described herein. Reference to a singular item,

includes the possibility that there are plural of the same items present. More specifically, as used herein and in claims associated hereto, the singular forms "a," "an," "said," and "the" include plural referents unless the specifically stated otherwise. In other words, use of the articles allow for "at least one" of the subject item in the description above as well as claims associated with this disclosure. It is further noted that such claims may be drafted to exclude any optional element. As such, this statement is intended to serve as antecedent basis for use of such exclusive terminology as "solely," "only" and the like in connection with the recitation of claim elements, or use of a "negative" limitation.

Without the use of such exclusive terminology, the term "comprising" in claims associated with this disclosure shall allow for the inclusion of any additional element—irrespective of whether a given number of elements are enumerated in such claims, or the addition of a feature could be regarded as transforming the nature of an element set forth in such claims. Except as specifically defined herein, all technical and scientific terms used herein are to be given as broad a commonly understood meaning as possible while maintaining claim validity.

The breadth of the present invention is not to be limited to the examples provided and/or the subject specification, but rather only by the scope of claim language associated with this disclosure.

The invention claimed is:

1. A method performed by a mobile computing system, the method comprising:

determining a computing experience for a user of the mobile computing system;

establishing a wireless connection between the mobile computing system and each of a plurality of wireless devices, wherein each respective wireless device is in proximity to a travel route of the mobile computing system;

receiving, over each respective wireless connection between the mobile computing system and a respective wireless device, location-based information that is associated with a respective location of the respective wireless device in proximity to the travel route, wherein at least a portion of the location-based information that is associated with the respective location of the respective wireless device is stored locally on the respective wireless device before establishing the wireless connection; and

presenting, through a display of the mobile computing system, the location-based information received from each of the plurality of wireless devices, wherein the location-based information is presented according to the determined computing experience.

2. The method of claim 1, wherein determining the computing experience includes receiving a selection of the computing experience that is made by the user through the mobile computing system.

3. The method of claim 1, wherein determining the computing experience includes:

accessing at least one data source that stores a schedule of the user; and

inferring the computing experience based at least partly on the schedule of the user.

4. The method of claim 1, wherein:

at least two of the plurality of wireless devices are at different locations in proximity to the travel route; and

the respective location-based information received from each of the at least two wireless devices is presented, through the display, during different periods of time.

5. The method of claim 1, wherein:

the computing experience includes at least one regulation that indicates at least: i) a first type of content to be displayed while the computing experience is employed, and ii) a second type of content to not be displayed while the computing experience is employed; and

presenting the location-based information includes presenting the first type of content and not presenting the second type of content.

6. The method of claim 1, wherein at least a portion of the location-based information that is associated with the location of the respective wireless device is presented to the user as an outline of a feature within the location.

7. The method of claim 1, wherein the mobile computing system is a wearable computing device.

8. The method of claim 1, wherein at least a portion of the location-based information that is associated with the location of the respective wireless device is communicated to the mobile computing system responsive to the mobile computing system scanning a marker that is proximal to the location.

9. The method of claim 8, wherein at least the portion of the location-based information is communicated to the mobile computing system from a cloud-based storage system.

10. The method of claim 1, wherein:

the display of the mobile computing system is an augmented reality display or a mixed reality display;

the location-based information sent from the respective wireless device includes geometric information associated with a feature in proximity to the location of the respective wireless device; and

presenting the location-based information includes using the geometric information to present a virtual representation of the feature in the display.

11. A mobile computing system comprising:

a display;

at least one processor communicatively coupled to the display; and

memory communicatively coupled to the at least one processor, the memory storing instructions which, when executed by the at least one processor, cause the at least one processor to perform operations comprising:

determining a computing experience for a user of the mobile computing system;

establishing a wireless connection between the mobile computing system and each of a plurality of wireless devices, wherein each respective wireless device is in proximity to a travel route of the mobile computing system;

receiving, over each respective wireless connection between the mobile computing system and a respective wireless device, location-based information that is associated with a location of the respective wireless device in proximity to the travel route, wherein at least a portion of the location-based information that is associated with the location of the respective wireless device is stored locally on the respective wireless device before establishing the wireless connection; and

presenting, through the display, the location-based information received from each of the plurality of wireless devices, wherein the location-based information is presented according to the determined computing experience.

**12**. The system of claim **11**, wherein determining the computing experience includes receiving a selection of the computing experience that is made by the user through the mobile computing system.

**13**. The system of claim **11**, wherein determining the computing experience includes:

accessing at least one data source that stores a schedule of the user; and

inferring the computing experience based at least partly on the schedule of the user.

**14**. The system of claim **11**, wherein:

at least two of the plurality of wireless devices are at different locations in proximity to the travel route; and

the respective location-based information received from each of the at least two wireless devices is presented, through the display, during different periods of time.

**15**. The system of claim **11**, wherein:

the computing experience includes at least one regulation that indicates at least: i) a first type of content to be displayed while the computing experience is employed, and ii) a second type of content to not be displayed while the computing experience is employed; and

presenting the location-based information includes presenting the first type of content and not presenting the second type of content.

**16**. The system of claim **11**, wherein at least a portion of the location-based information that is associated with the

location of the respective wireless device is presented to the user as an outline of a feature within the location.

**17**. The system of claim **11**, wherein the mobile computing system is a wearable computing device.

**18**. The system of claim **11**, wherein at least a portion of the location-based information that is associated with the location of the respective wireless device is communicated to the mobile computing system responsive to the mobile computing system scanning a marker that is proximal to the location.

**19**. The system of claim **18**, wherein at least the portion of the location-based information is communicated to the mobile computing system from a cloud-based storage system.

**20**. The system of claim **11**, wherein:

the display of the mobile computing system is an augmented reality display or a mixed reality display;

the location-based information sent from the respective wireless device includes geometric information associated with a feature in proximity to the location of the respective wireless device; and

presenting the location-based information includes using the geometric information to present a virtual representation of the feature in the display.

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